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John Day Drawdown
Phase I Study

Economic Analysis Technical Appendix
Commercial Fishing Section






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JOHN DAY DAM DRAWDOWN PHASE 1 STUDY

ECONOMIC EVALUATION OF CHANGED ANADROMOUS FISH HARVESTS DUE TO JOHN DAY DAM ALTERNATIVE HYDROSYSTEM ACTIONS

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1. INTRODUCTION

The Portland District of the U.S. Army Corps of Engineers (Corps) is studying alternatives for lowering the pool behind the John Day Dam on the Columbia River. The purpose of the study is to show how the alternatives affect the survival rates of threatened and endangered stocks of anadromous fish. The study is at a "feasibility" level and will be the basis for a recommendation to Congress about the need for further, more detailed study. This section of the study report describes the economic evaluation for changes to harvests of anadromous fish impacted by the alternative hydrosystem actions.

The alternative hydrosystem actions are described in Table 1. The two main alternatives are restore the pool area to natural river (referenced as Action B1) and lower the pool behind the Dam to spillway crest (referenced as Action B2). Under the natural river alternative, the pool elevation is taken to the level of The Dalles Dam pool at the John Day Dam tailrace. The second alternative draws the pool down to the crest of the John Day Dam spillway. A third alternative (referenced as Action B3) is for using flood control facilities for the natural river alternative. The alternatives are modeled with the assumption that the lower Snake River dams are being breached in tandem with modifications being made to the John Day Dam. The existing situation, or "base case," is for the John Day Dam and the lower Snake River dams to remain as they currently operate (referenced as Action A1).

Table 1. Alternative Hydrosystem Actions

Action Identifier	Action Description
A1	John Day Dam and lower Snake River dams as currently operated
B1	Natural river drawdown of four lower Snake River dams and John Day drawdown to natural level
B2	Natural river drawdown of four lower Snake River dams and John Day drawdown to spillway crest
B3	Natural river drawdown of four lower Snake River dams and John Day drawdown to natural river with flood control

Notes:
1. The physical conditions of the John Day Dam pool for Action A1 (existing water management) are 51,409 acres and contain approximately 1,113 acres of anadromous fish spawning habitat.
2. The physical conditions for Action B1 (natural river drawdown) are for the pool elevation to be taken down to the level of The Dalles Dam pool at the John Day Dam tailrace. The natural channel at the tailrace is at an elevation of 139 feet. Current minimum tailwater elevation is 155 feet. During a two year flood, the tailwater elevation is 166 feet and, under the 20 year flood, it is 172 feet. Under these conditions, the natural river elevation would vary between 155 and 172 feet. Taking the typical elevation of the natural river as 165 feet, the natural river elevation drop is 100 feet. The river surface area would become 26,505 acres. The spawning habitat for anadromous fish is 11,170 acres.
3. The physical conditions for Action B2 (spillway crest) draw the pool down to the crest of the John Day Dam spillway at 210 feet. Fish would pass through the spillway and plunge 50 feet down into the tailrace at an elevation of about 160 feet. The full pool elevation is

between 257 and 268 feet, giving a spillway crest drawdown level of approximately 50 feet, assuming a typical operating pool elevation of 265 feet and a forebay elevation 5 feet above the crest. The pool behind the dam would have a surface area of 33,307 acres. The size of the anadromous fish spawning habitat is 6,296 acres.

4. The John Day Dam pool is used for flood control and has a capacity under current operating conditions to store 534,000 acre-feet. The temporary storage of this amount of water requires lowering the elevation in anticipation of a flood event and then raising the level to approximately full pool. The net elevation change is approximately 10 feet. This level of flood control was sufficient to manage the 1997 spring runoff, which was one of the largest on record. The physical conditions for Action B3 (natural river with flood control facilities) are for the pool elevation to increase approximately 20 feet.

Source: Willis (2000).

In addition to the economic evaluation of changes to impacted anadromous fish runs due to the alternatives, this section of the study report also presents background information about all Columbia River Basin salmon and steelhead fish runs, harvests, and their economic values. This background information is summarized in Chapter II and explained in more detail in Attachment A. Other appendices provide more detailed information about economic evaluation methods and the history for mitigating the loss of anadromous fish habitat inundated by the John Day Dam Pool.

The economic evaluation of the alternatives is expressed as net economic values, or the National Economic Development (NED) accounting stance used by the Corps. Commercial and recreational fishing for Columbia River Basin anadromous fish stocks generates a significant amount of household personal income in the region as well as having the national economic benefits. The regional economic impacts of the alternatives, or the regional economic development (RED) accounting stance used by the Corps, are presented in a separate section of the study report titled Regional Economic Analysis. The background information about all salmon and steelhead fisheries is expressed in both RED and NED measures.

The economic evaluation is for all major anadromous fish stocks affected by altering the John Day Dam. This includes wild stocks, natural stocks, and hatchery stocks originating upstream of the John Day Dam in the Columbia River Basin.[1] The major anadromous fish stocks are defined to be spring/summer and fall chinook salmon *(Oncorhynchus tshawytscha),* and winter and summer steelhead *(O. mykiss)*. Other anadromous fish, such as shad *(Alosa sapidissima)*, sturgeon *(Acipenser transmontanus* and *A. medirostris)*, coho salmon *(O. kisutch)*, sockeye salmon *(O. nerka)*, etc., would not have fisheries significantly changed by the hydrosystem actions. All utilization of both wild and hatchery

1. Anadromous fish stocks originating from spawning habitat can be designated as "wild" and "natural" demes or stocks, according to Chapman et al. (1991). Wild stocks have genetic makeup unlikely to have been altered by hatchery fish. Natural stocks are naturally spawning fish that have genetically mixed with hatchery fish. For example in the Snake River Basin, 23 natural and wild spring chinook and nine summer chinook stocks were identified by Chapman et al. (1991). Stocks of hatchery origin include 12 spring chinook stocks and two summer chinook stocks. One natural population of fall chinook has been identified. Since effects from altering the hydrosystem cannot be differentiated between wild and natural stocks, this section of the study report refers to both types as wild stocks.

originating stocks was considered. This includes commercial and recreational harvests, as well as sales of hatchery egg, carcass, and surplus fish.

2. COLUMBIA RIVER ANADROMOUS FISH FISHERIES

Historically, anadromous fish were harvested as adults in the Columbia River. Today, salmon produced in the Columbia River watershed are harvested from California to Alaska. Commercial fishing vessels use troll gear, set nets, and other methods to harvest the salmon and steelhead that are swimming in mixed stocks. Recreational anglers using single poles in the ocean take a share of Columbia River produced fish. Columbia River spawned anadromous fish are also caught incidentally in other marine fisheries.

The harvests of Columbia River produced anadromous fish that are mixed with other stocks occur all along the west coast of North America.[1] The trends in number of salmon and steelhead caught in the ocean by user group and by species are shown in Figure 1 and Figure 2, respectively.[2] The ex-vessel values by area for select periods are shown in Figure 3. Most of the increase in commercially harvested anadromous fish has occurred in Alaska. Declining wild runs in British Columbia and on the U.S. West Coast have significantly decreased ocean fisheries, but on a site, species, and origin (natural or hatchery) specific basis.

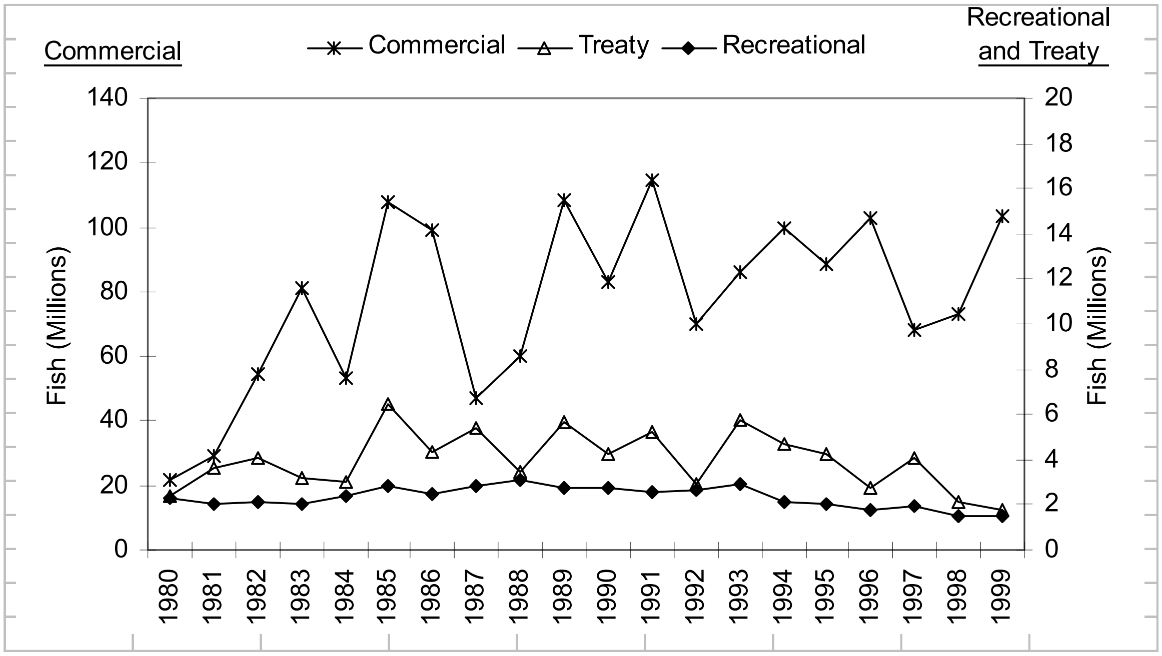
The commercial and recreational anadromous fish fisheries are very important for some coastal communities in North America. Figure 4 shows the relative size contribution of the economic impacts by user groups.[3,4] Table 2 compares the personal income generated from anadromous fish commercial, recreational, and treaty fishing to total personal income in the province and states. The average annual personal income generated by ocean commercial, recreational, and treaty fisheries was about $762 million in the late 1990's. This is less than one percent of personal income from all sources during this period. The percentage is far less when considering only the U.S. West Coast states.

The economic impacts attributable to Columbia River produced anadromous fish is presented in Attachment A, Chapter V. The Columbia River production for the early

1. The geographical region is inclusive of the following subareas: southeast Alaska, west coast of Vancouver Island, coastal British Columbia, coastal Washington, Puget Sound, coastal Oregon, and coastal California. The economic information about fisheries in these subareas is only for ocean harvest areas and excludes commercial, recreational, and treaty fisheries that take place inriver.
2. The sources of information for historical salmon and steelhead harvests are Pacific Fishery Management Council (PFMC), "Review of 1999 Ocean Salmon Fisheries," February 2000; Fisheries and Oceans of Canada (FOC), "1998 Post-Season Review: Status of Salmon Spawning Levels," March 12, 1999; personal communication with FOC, Catch Statistics Unit; and Alaska Department of Fish and Game, website extractions.
3. The economic effects were calculated using user specific per fish ratios from various recent economic analysis studies, including Jones & Stokes Associates Inc. (1991), The ARA Consulting Group Inc. (1996), and PFMC (2000). The ratios were adjusted to 1999 dollars using the GDP implicit price deflator developed by the U.S. Bureau of Economic Analysis and Canadian to U.S. dollar currency conversion rates.
4. The economic effects are measured as regional economic impacts, which correspond to Regional Economic Development (RED) benefits used as an accounting stance by the Corps.

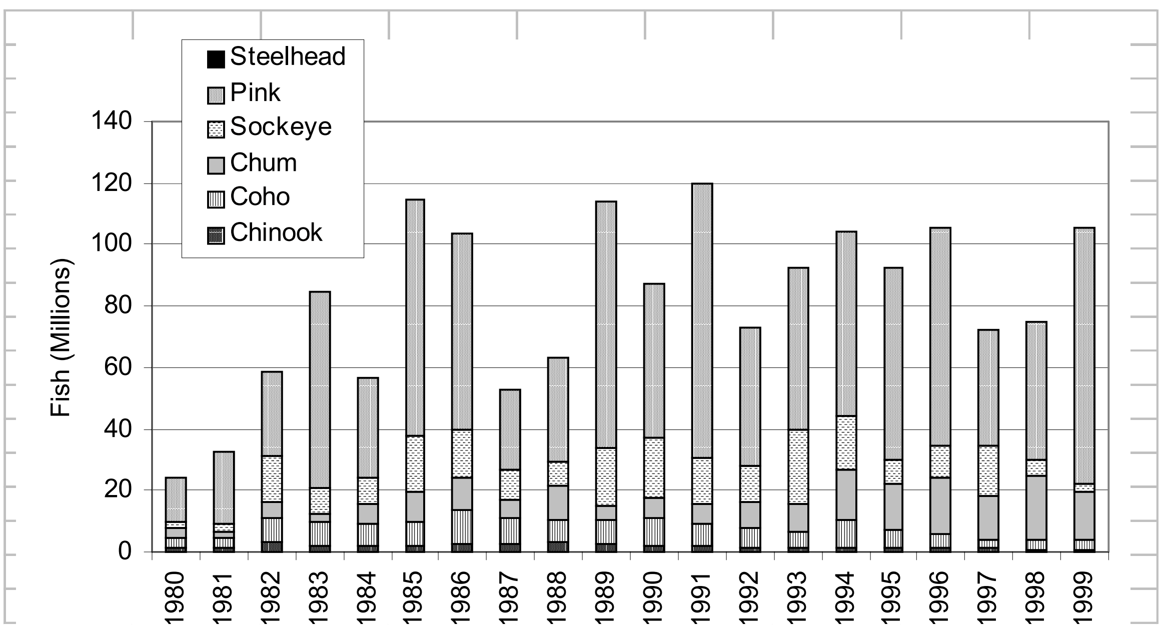
1990's contributed about $38 million to coastal communities in North America. (This economic impact includes inriver commercial, recreational, and treaty fisheries.) Anadromous fish production in the Columbia River has shifted from mostly wild spring and summer chinook to hatchery fall chinook and coho. Because fall chinook are harvested in ocean fisheries while spring and summer chinook are not, a larger share of economic impacts is being exported out of the Columbia River inland region under current hatchery management policies.

Figure 1. Annual Salmon and Steelhead Harvest by User Group on the West Coast of North America in 1980 to 1999



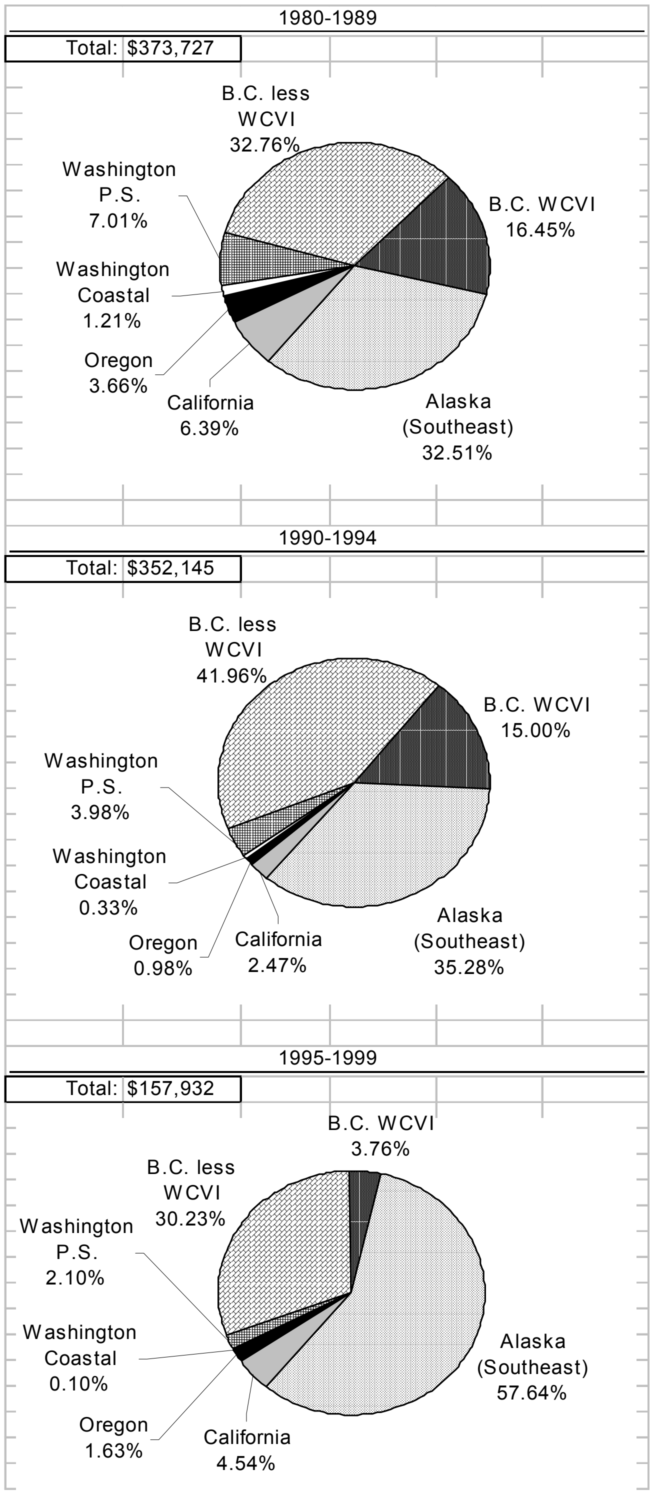
Note: Treaty includes U.S. treaty Indian and Canadian First Nations harvest.

Figure 2. Annual Commercial Salmon and Steelhead Harvest by Species Along the West Coast of North America in 1980 to 1999



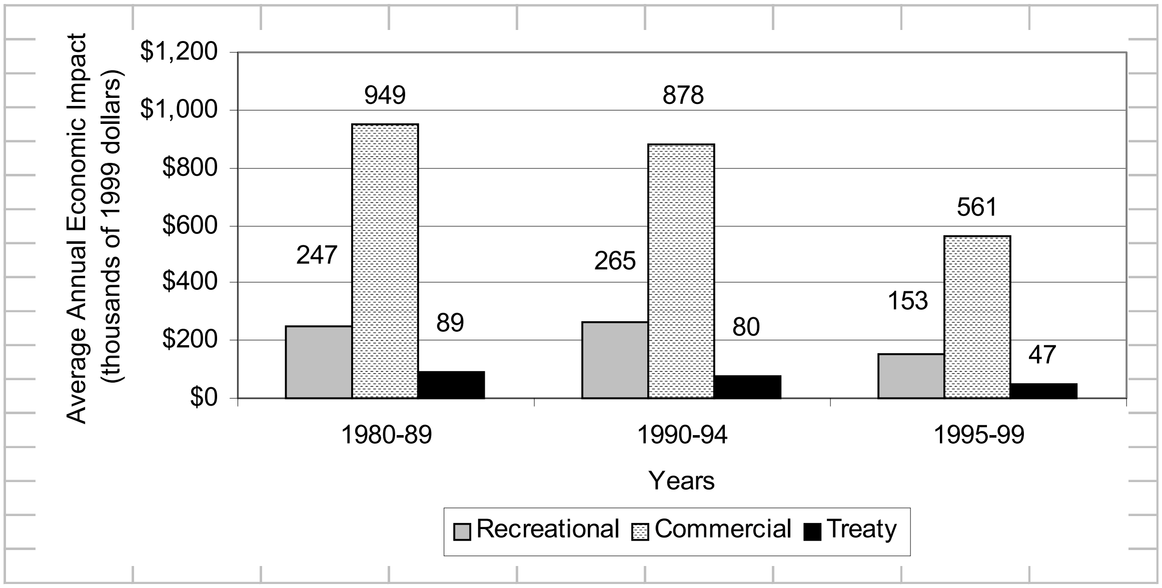
Note: Commercial harvests do not include U.S. treaty Indian and Canadian First Nations harvest.

Figure 3. Salmon and Steelhead Marine Fisheries Average Annual Commercial (Non-Indian)
Ex-vessel Value by Gear and by Species for Select 5-year Average Periods



Notes: 1. Total ex-vessel value is in thousands of 1999 dollars adjusted using the GDP Implicit Price Deflator developed by the U.S. Bureau of Economic Analysis and Canadian to U.S. dollars currency exchange rates.
2. WCVI is West Coast Vancouver Island, P.S. is Puget Sound.

Figure 4. Average Annual Economic Impacts From Salmon and Steelhead Fisheries by User Group for All Regions During Select Periods



Note: Treaty includes U.S. treaty Indian and Canadian First Nation harvests.

Table 2. Average Annual Share of Economic Impacts From All Fisheries' User Groups Compared to Total Personal Income During the Period 1995 to 1999

	Total	Personal Income From Fisheries							
	Personal	Total		Commercial		Recreational		Treaty Indian	
State or Province	Income	Amount	Share	Amount	Share	Amount	Share	Amount	Share
California	933,521.5	39.5	0.00%	17.1	0.00%	21.8	0.00%	0.6	0.00%
Oregon	86,251.0	20.2	0.02%	5.1	0.01%	15.0	0.02%	0.0	0.00%
Washington	165,667.2	45.6	0.03%	11.0	0.01%	18.9	0.01%	15.7	0.01%
British Columbia	96,932.0	229.8	0.24%	145.8	0.15%	53.3	0.05%	30.8	0.03%
Alaska (Southeast)	2,212.1	426.5	19.28%	382.1	17.27%	44.4	2.01%	0.0	0.00%
Total	1,284,583.9	761.5	0.06%	561.1	0.04%	153.3	0.01%	47.1	0.00%

Notes:
1. Total personal income in millions of 1999 U.S. dollars is for 1998 (most recent year available).
2. Economic impacts from fishing is 5 year annual average, 1995-1999, in 1999 dollars adjusted using the GDP Implicit Price Deflator developed by the U.S. Bureau of Economic Analysis and Canadian to U.S. dollars currency exchange rates.
3. Much of the personal income is generated in waters off Alaska but flows to the State of Washington, especially the Seattle area.

Source: Study; personal income data from British Columbia, Provincial website publication Annual Provincial Economic Accounts 1998; and GEOSTAT Regional Economic Information System.

3. METHODOLOGY

3.1. Economic Valuation

The economic valuation of changed anadromous fish stock harvests relies on available methods and data. Economic valuation attempts to measure the benefits received by those that fish and the value people place on fishing. This is commonly called net economic value or NEV (net economic value above costs) and corresponds to national economic development or NED benefits used as an accounting stance by the Corps. NEV is important if the goal is to allocate society's resources efficiently. It may often be the case that society will want to invest in a less valuable resource because the local area or economy that holds that resource is in need of economic development. Nevertheless, having the information on economic value will tell society how much they are giving up in order to achieve the redistribution of economic activity or development.

Estimates of net economic value of commercial and recreational anadromous fishing are made using available studies and procedures developed by management agencies, such as Oregon Department of Fish and Wildlife (ODFW), Pacific Fishery Management Council (PFMC), and the National Marine Fisheries Service (NMFS). Commercial fisheries evaluations use ex-vessel value of the fish as a proxy indicator for the value. Seventy percent of ex-vessel revenue is used as the indicator. The remaining 30 percent represents additional expenses of harvesting and primary processing required to produce a consumer product from Columbia River Basin anadromous fish runs. Recreational fisheries evaluation uses a benefit-transfer approach for an angler day value. The basis of a benefit-transfer approach is that other similar situations for fishing experiences are correctly evaluated and are directly comparable to another situation.

Estimates of NEV for anadromous fish harvesting are based on a per fish value for commercial fishing, and per angler day value for recreational fishing. These unit values and recreational success rates by fisheries are shown in Table 3. Estimates of NEV utilized in this paper should be viewed as general values; specific uses in selective areas may change these values. A more detailed explanation of assumptions and methods used to derive these values is presented in Attachment B.

3.2. Harvest Distribution Assumptions

The forecast of fish available for harvest in the ocean and in-river is distributed to user groups within constraints of international understandings and Columbia River tribal treaty agreements. Historical harvest distribution patterns were used as a base and then modified for future expected management regimes.

There are a host of salmon treaties and agreements that affect salmon of the Columbia River system. These can be categorized as *international understandings*, such as the 1992 International North Pacific Fisheries Commission Convention (Shepard and Argue 1998), the United Nations Convention on the Law of the Sea which entered into force in November 1994, the Pacific Salmon Treaty (PST) between the United States and Canada, *harvest management agreement processes* such as the PFMC, *agreements to rebuild the stocks* such as the Northwest

Table 3. Economic Assumptions

Species/Fishery	Economic Values: Commercial	Economic Values: Recreational	Success Rates: Recreational
Spring/Summer Chinook			
Ocean			
Alaska	33.83		
British Columbia	34.30		
Washington ocean	23.68		
Washington Puget Sound	21.19		
Oregon	21.65		
California	22.33		
Columbia Basin inland			
Mainstem	49.95	51.43	3
Tributary		63.23	5
Other	0.00		
Food Fish	26.87		
Carcass and egg sales	0.00		
Fall Chinook			
Ocean			
Alaska	33.83	51.43	1
British Columbia	34.30	51.43	1
Washington ocean	23.68	51.43	1
Washington Puget Sound	21.19	51.43	1
Oregon	21.65	51.43	1
California	22.53	51.43	1
Columbia Basin inland			
Mainstem	23.53	51.43	3
Tributary			
Other	0.00		
Food Fish	18.25		
Carcass and egg sales	1.23		
Summer Steelhead			
Ocean			
Alaska			
British Columbia	11.44		
Washington ocean			
Washington Puget Sound			
Oregon			
California			
Columbia Basin inland			
Mainstem	9.99	52.85	3
Tributary		63.23	5
Other			
Food Fish	8.73		
Carcass and egg sales	1.23		

Notes: 1. Average 1998 dollars per fish for commercial fisheries and per angler day for recreational fisheries.
2. Carcass sale value estimated to be $0.10 per pound for whole body fish less eggs.

Source: Study.

Power Planning Act, *court decisions* that have defined the obligations to Northwest Indian Tribes, and most recently *federal mandates to protect salmon* stocks under the Endangered Species Act (ESA). The forecast of future anadromous fish run sizes produced from the Snake River and the entire Columbia River system used in this study has taken into consideration the international understandings for assumptions about salmon production, allocation agreements, and protection of natural runs.[1]

There are three basic distribution patterns of Columbia River Basin produced salmon: north turning fish (fall chinook), south turning fish (coho), and some that tend to migrate in either direction (some of the above). Steelhead tend to scatter and migrate as far as Russian waters. Harvest rates by geographic area depend on migration patterns, as well as historic fishing patterns, and on international and historic treaties and management policies. The distributional criteria assume that future harvests will reflect recent historical catches in ocean and terminal fisheries where these fish migrate. This assumption, however, depends on the present Columbia River user group allocations. The distributional assumptions under conditions of "80's runs" are used to assign harvestable fish to user groups (Table 4).

The anadromous fish forecasting analysis results in a fairly large share of summer steelhead destined to the Snake River watershed escaping fisheries and returning to hatcheries as surplus. The default use of this surplus is for food fish, egg, and carcass sales. There may be fishery management opportunities to convert these sales to harvest, however drastic changes to management regimes to take advantage of these opportunities were not included in the analysis.

3.3. Historical John Day Dam Pool Area Anadromous Fish Production

John Day Dam construction started in 1958 and river flow started impounding in 1967. The Pool reached operating levels in 1968. Prior to construction, records indicate that 30,000 adult fall chinook salmon spawned in the area flooded by the dam. In 1978 the states, federal agencies, and U.S. Army Corps of Engineers reached agreement on chinook mitigation due for the John Day project. The agreed mitigation was for 30,000 adult fall chinook spawners and all harvested fish produced by this annual escapement. Hansen (1991) reports:

> "On July 20, 1965, a meeting was held in Portland, Oregon, regarding the mitigative aspects related to the inundation of chinook salmon spawning area - John Day Dam and Reservoir. In attendance at the meeting were representatives of the various fishery agencies as well as representatives from the Corps. At this meeting, it was generally agreed that fish hatchery

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1. Harvest allocations set by fishery management plans and treaties can change. For example, the U.S. is presently negotiating with Canada on harvest allocations. It is not clear what new harvest allocations will result from these negotiations. For that reason, existing U.S. and Indian tribal agreements are the base used in allocating harvests. In the case of inriver tribal agreements, harvests are now less than treaty rights for 50 percent of harvestable summer steelhead stocks. Future distributional allocations were modified to attain a 50 percent share within 25 years.

facilities should be constructed that could care for adequately 30,000 adult chinook salmon with incubation facilities for 75 million eggs and rearing facilities that could produce 60 million juveniles at 100 per pound at time of planting, or 600,000 pounds of fall chinook salmon juveniles (U.S. Fish and Wildlife Service 1965, and U.S. Army Corps of Engineers 1994)."[1]

Table 4. Distributional Assumptions

		Distributional Assumptions					
		Spring/Summer Chinook		Fall Chinook		Summer Steelhead	
Geographic Region/Fishery		Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
Ocean							
Alaska							
	Commercial	3.198%	14.017%	6.804%	7.206%	0.000%	0.000%
	Recreational	0.000%	0.000%	0.011%	0.012%	0.033%	0.065%
British Columbia							
	Commercial	6.397%	28.039%	28.350%	30.027%	1.084%	2.143%
	Recreational	0.640%	2.805%	2.268%	2.402%	0.000%	0.000%
Washington Ocean							
	Commercial	1.279%	5.606%	5.342%	5.658%	0.000%	0.000%
	Recreational	1.279%	5.606%	2.374%	2.514%	0.000%	0.000%
Washington Puget Sound							
	Commercial	0.640%	2.805%	0.001%	0.001%	0.000%	0.000%
	Recreational	0.000%	0.000%	0.001%	0.001%	0.000%	0.000%
Oregon							
	Commercial	0.640%	2.805%	1.781%	1.886%	0.000%	0.000%
	Recreational	0.640%	2.805%	0.594%	0.629%	0.033%	0.065%
California							
	Commercial	0.000%	0.000%	0.001%	0.001%	0.000%	0.000%
	Recreational	0.000%	0.000%	0.001%	0.001%	0.000%	0.000%
Columbia Basin Inland							
Recreational							
	Mainstem	0.000%	0.000%	1.187%	1.257%	7.414%	14.659%
	Tributary	0.000%	0.000%	0.000%	0.000%	22.242%	43.977%
Commercial							
	Gillnet	0.000%	0.000%	14.245%	15.088%	0.000%	0.000%
	Tribal	4.264%	18.689%	31.283%	33.134%	19.770%	39.090%
Other		3.838%	16.822%	0.172%	0.182%	0.000%	0.000%
Hatchery							
	Egg & Carcass	38.593%	0.000%	2.793%	0.000%	24.713%	0.000%
	Food Fish	38.593%	0.000%	2.793%	0.000%	24.713%	0.000%

Notes: 1. Distributional assumptions for wild stocks are calculated as a percentage of hatchery stocks less egg & carcass and food fish. This is done to ensure that all harvestable wild fish are captured in the analysis.
2. Distribution patterns reflect 1980's runs modified to meet existing fishery management plans and international and Indian treaty obligations.

Source: Study.

1. John Day mitigation history, from Technical Advisory Committee (1997). See Attachment C for a more complete description of mitigation history.

Losses in spawning habitat due to construction and operation of John Day Dam are mitigated with annual hatchery production. The Spring Creek Hatchery, located on the Washington shore of the Columbia River in the Bonneville Dam pool operated by the U.S. Fish and Wildlife Service, and Bonneville Hatchery, located on the Oregon shore immediately below Bonneville Dam and operated by the Oregon Department of Fish and Wildlife, made up the bulk of the production. In recent years, the Little White Salmon Hatchery, also in Washington, has been operated as a unit with the Spring Creek Hatchery. Little White Salmon Hatchery produces the upriver bright fall chinook salmon for the John Day mitigation and Spring Creek Hatchery produces tule (lower river) fall chinook salmon. The agreement for operating the Spring Creek National Fish went into effect in 1972 and the agreement for operating the Bonneville Salmon Hatchery went into effect in 1978.

The Corps' original estimate and mitigation agreement based on 30,000 fall chinook salmon spawners was derived by taking the difference between the fish counts at The Dalles and McNary dams for the years 1957-1964 and adding an additional 20 percent safety factor. At first, the fisheries agencies reared tule fall chinook salmon for John Day mitigation. Recently, upriver bright fall chinook are being reared in the hatcheries and a portion of the smolts are transported upriver for acclimation and release in the Hanford Reach so returning adults will provide an upstream fishery for the tribes. Releases of juvenile fish from the various facilities compensated under John Day dam mitigation currently represent approximately 11.9 million smolts annually. These releases are approximately 4 times greater than the anticipated smolt yield from 30,000 adult spawning naturally.

4. HARVEST FORECAST

Harvest forecast methods utilize passage models to characterize the survival through the hydrosystem and then incorporate the passage model results into life cycle models to characterize the effect of water management actions on adult population levels. Specific changes in harvestable adults and returning spawners related to water management alternatives were based on estimates for a selected few wild origin index stocks provided by Anderson et al. (1999) and summarized by Willis (2000).[1] The effects to the index stocks were used as a basis to extend the analysis to represent all wild and hatchery origin stocks. The methods and forecast results are explained in two following sections related to effects from passage improvements and habitat re-creation in the John Day Dam pool area.

4.1. Passage Improvement

To produce impact estimates of John Day Dam actions on adult population levels, Anderson et al. (1999) simplified the analysis provided by PATH to produce mean

1. Pertinent excerpts of these studies are repeated for clarity in discussing the economic valuation and harvest forecast methods.

equilibrium harvest and spawner levels under a range of hypotheses.[1] For the more detailed analyses of actions at the John Day project, Anderson et al. (1999) further refined the life-cycle analyses to produce only the difference in adults under two actions. This simplification arises from the assumption that actions taken at the John Day project will not affect survivals in other life stages (e.g., ocean survival or egg to smolt survival) with the result that these survivals will cancel out when comparing two actions.

The equilibrium measure of the population is the level at which the spawning recruits of a brood are exactly sufficient to replace their parental brood. With typical salmon life-cycle models, in the absence of environmental variations and a constant harvest rate, the equilibrium population level is a stable point that a stock will approach over time. Simply put, the equilibrium is a measure of the number of fish a habitat can maintain with a specific set of management actions including hydrosystem operations and fisheries regulations.

The time period of anadromous fish recovery to reach equilibrium may differ depending on physical conditions, fishery management, and other factors. An undefined time period, following altered river hydraulics, may be needed to return the river bed conditions to acceptable spawning habitat quality. Whereas the river will cut through the soft sediments relatively quickly and create the surface layer of appropriate spawning gravels, it may take a large flood to scour the streambed to sufficient depth to clear embedded fine materials. Similarly, a demographic lag of many generations may occur at current commercial fish harvest rates prior to achieving spawning levels approaching full capacity. Following the geomorphologic changes, the transition for a drawdown to reestablish a macro invertebrate community to supply food to rearing fall chinook may take 10 years, according to research provided by PATH. Anderson et al. (1999) also suggests a 10 year demographic response for fall chinook to reach an equilibrium level. Given the suggested ranges for geomorphologic changes, microinvertebrate changes, and demographic responses, the time period to recovery for economic calculations is assumed to be 30 years.

Modeling assumptions were required for estimating the near term changes between existing conditions and the Year 30 equilibrium levels. For wild anadromous fish stocks, a Logistic Growth Curve was fit to Year 0 starting values and Year 30 equilibrium levels (Seber 1984). For hatchery stocks, the rate of change in survival rates for the first generation of

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1. The Plan for Analyzing and Testing Hypotheses (PATH) process intended to identify, address, and (to the maximum extent possible) resolve uncertainties in the fundamental biological issues surrounding recovery of endangered spring/summer chinook, fall chinook, and summer steelhead stocks in the Columbia River Basin. The PATH process used a committee approach to discuss and resolve issues. The committee membership were representatives of agencies that regulate or have an interest in anadromous fish runs. The committee was staffed by consultants. The PATH modeled the survival of some of the Snake River wild spring and summer chinook stocks and fall chinook stocks to determine the effects of the hydrosystem actions. PATH developed a quantitative decision analysis framework for spring/summer chinook and a preliminary framework for fall chinook. The process also developed a qualitative analysis for summer steelhead using comparisons of the likely effects of actions on spring/summer chinook as a guide to the probable response of summer steelhead. The PATH decision analysis focused on the probability to which alternative hydrosystem actions contributed to preventing extinction and aiding recovery of stocks either listed or proposed for listing.

wild stocks (Year 0 existing conditions and estimated Year 5 equilibrium levels) was applied to existing hatchery origin anadromous fish survival rates. Hatchery production is assumed to be constant, so typical spawner-recruit relationships do not apply.

It was necessary to expand the provided index wild stocks from the upper Columbia River and Snake River to represent all other significant wild stocks affected by the John Day Dam alterations.[1] Also, the actions intended to increase wild anadromous fish survival would increase hatchery fish survival so it was necessary to add all effected hatchery origin stocks. The changes in survival rates for the index wild stocks are used to model similar life cycle stocks, e.g. Snake River spring chinook estimates are used for Snake River summer chinook. There are no estimates for increased steelhead survival rates given in the Anderson et al. (1999) report. The assumption used for the economic analysis is that summer and winter steelhead will survive at 37 percent of comparable spring/summer chinook stocks.[2] The equilibrium harvests for all the affected stocks are shown in Table 5. The largest increase in harvests results from recreating spawning areas accessible to fall chinook in the John Day Dam pool area.

1. There are probably beneficial effects for middle Columbia River stocks, as well as upper Columbia River and Snake River stocks. However, no biological modeling for these stocks was performed for this preliminary assessment. Therefore, the survival rates are assumed not to change for the middle Columbia spring chinook and summer steelhead spawning in the tributaries, such as John Day, Umatilla, etc.
2. The PATH process did not develop harvest and spawner impact information for steelhead, but did provide a comparative analysis between summer steelhead and spring/summer chinook. The analysis concluded actions that benefit spring/summer chinook are likely to benefit steelhead as well. The relative decline for summer steelhead has been proportionately less than the decline for spring/summer chinook. It would be reasonable to presume that the response to actions that address the factors for decline would be proportionately less (to the same degree as during the decline) for summer steelhead than for spring chinook. It was therefore assumed that the survival rate response for steelhead would be reduced relative to that for spring chinook by a proportionality constant reflecting the relative historical decline. The current best estimates of the ratios of recent survival rates to historical survival rates are 11.2x for spring/summer chinook and 4.1x for steelhead (Cooney 1999). Using those ratios, the proportional change in steelhead survival rates is about 0.37 times the change in spring chinook survival rates.

Table 5. Equilibrium Level Harvestable Fish Resulting From John Day Dam Hydrosystem Actions

	Historical	Harvest at Equilibrium Year 30		
	Harvest	Harvest		Difference
Species/Stocks	Year 0	A1	Bx	A1-Bx
Natural River (B1)				
Wild Index Stocks				
SR Spring Chinook	1,115	3,534	14,820	11,286
SR Fall Chinook	1,408	6,548	81,140	74,592
Hanford Reach Fall Chinook	240,272	214,640	140,659	(73,981)
UC Spring Chinook	369	369	460	91
New Habitat Fall Chinook	13,337	13,337	172,565	159,228
Other Wild Stocks				
SR Summer Chinook	195	617	2,587	1,970
SR Summer Steelhead	4,115	7,417	22,826	15,408
UC Summer Chinook	673	673	839	166
UC Fall Chinook	45,260	40,432	26,496	(13,936)
UC Summer Steelhead	8,055	8,055	8,790	735
UC Spring Chinook (Other)	0	0	0	0
Hatchery Stocks				
SR Spring Chinook	2,124	2,891	6,473	3,582
SR Fall Chinook	3,409	5,483	35,581	30,098
SR Summer Chinook	116	158	354	196
SR Summer Steelhead	76,953	87,245	135,269	48,024
UC Summer Chinook	85	85	88	3
UC Fall Chinook	37,945	37,270	35,323	(1,947)
UC Summer Steelhead	55,926	55,926	56,777	851
UC Spring Chinook (All)	0	0	0	0
Spillway Crest (B2)				
Wild Index Stocks				
SR Spring Chinook	1,115	3,534	12,844	9,310
SR Fall Chinook	1,408	6,548	78,394	71,846
Hanford Reach Fall Chinook	240,272	214,640	130,544	(84,096)
UC Spring Chinook	369	369	416	47
New Habitat Fall Chinook	13,337	13,337	86,602	73,265
Other Wild Stocks				
SR Summer Chinook	195	617	2,242	1,625
SR Summer Steelhead	4,115	7,417	20,128	12,711
UC Summer Chinook	673	673	759	86
UC Fall Chinook	45,260	40,432	24,591	(15,841)
UC Summer Steelhead	8,055	8,055	8,435	380
UC Spring Chinook (All)	0	0	0	0
Hatchery Stocks				
SR Spring Chinook	2,124	2,891	5,846	2,955
SR Fall Chinook	3,409	5,483	34,473	28,990
SR Summer Chinook	116	158	320	162
SR Summer Steelhead	76,953	87,245	126,861	39,616
UC Summer Chinook	85	85	87	2
UC Fall Chinook	37,945	37,270	35,057	(2,213)
UC Summer Steelhead	55,926	55,926	56,365	439
UC Spring Chinook (All)	0	0	0	0

(continued)

Species/Stocks	Historical Harvest Year 0	Harvest at Equilibrium Year 30 Harvest A1	Bx	Difference A1-Bx
Natural River With Flood Control (B3)				
Wild Index Stocks				
SR Spring Chinook	1,115	3,534	14,174	10,640
SR Fall Chinook	1,408	6,548	81,140	74,592
Hanford Reach Fall Chinook	240,272	214,640	140,659	(73,981)
UC Spring Chinook	369	369	437	68
New Habitat Fall Chinook	13,337	13,337	172,565	159,228
Other Wild Stocks				
SR Summer Chinook	195	617	2,475	1,858
SR Summer Steelhead	4,115	7,417	21,944	14,526
UC Summer Chinook	673	673	797	124
UC Fall Chinook	45,260	40,432	26,496	(13,936)
UC Summer Steelhead	8,055	8,055	8,604	549
UC Spring Chinook (All)	0	0	0	0
Hatchery Stocks				
SR Spring Chinook	2,124	2,891	6,268	3,377
SR Fall Chinook	3,409	5,483	35,581	30,098
SR Summer Chinook	116	158	343	185
SR Summer Steelhead	76,953	87,245	132,520	45,275
UC Summer Chinook	85	85	87	3
UC Fall Chinook	37,945	37,270	35,323	(1,947)
UC Summer Steelhead	55,926	55,926	56,562	636
UC Spring Chinook (All)	0	0	0	0

Notes:
1. UC - Upper Columbia; SR - Snake River.
2. A1 refers to the John Day Dam and the lower Snake River dams as they are currently operated.
3. Bx refers to either John Day Dam Action B1, B2, or B3. B1 refers to natural river drawdown. B2 refers to drawdown to spillway crest. B3 refers to natural river drawdown with flood control. All actions assume the lower Snake River dams are being breached in tandem with the John Day Dam.
4. Harvest includes both ocean and inriver harvest.
5. Snake River and Upper Columbia steelhead are estimated based on the assumption that steelhead survive at 37 percent of the rate change for spring and summer chinook.
6. Hatchery stocks rate change assumes one five year increment rate change of comparable species wild stock.
7. Equilibrium year for wild and hatchery stocks is year 30 and year 5 respectively.
8. Year 0 information is from most recent 10 year historical average.

Source: Study; TAC; Anderson et al. (1999), Tables 29, 31, 34, 35, 38, 39, 41, and 42.

4.2. John Day Dam Pool Area Habitat Improvement

A review of potential effects on spawning adult salmonids from improved habitat resulting from John Day Dam water management actions was completed by Willis (2000). The review describes the effects of various drawdown scenarios on spawning salmonid fishes by evaluating: 1) the species known to historically and currently use the John Day Dam reach for spawning, 2) the timing and duration of reservoir spawning, 3) estimating the potential change in the quantity and quality of spawning habitat conditions, and 4) estimating the increased capacity of the reach to produce salmonid fishes under alternative operating scenarios. "Drawdown to natural river . . . is anticipated to provide an approximate 8- to 10-fold increase in the fall chinook spawning capacity in the John Day reach compared to current levels of spawning. Drawdown to spill crest . . . is expected to achieve perhaps 50 to 75 percent of the benefit achieved under natural river conditions (Willis 2000) (Figure 5). Table 6 shows the forecasted spawners and number of fish available for ocean and terminal fisheries harvest. The existing pool area spawning is only for fall chinook salmon. The drawdown to spillway crest or natural river levels is also assumed to only benefit the fall chinook race that extensively uses large mainstem rivers for spawning.

Subtracting the equilibrium spawning population size required to replace itself from the predicted total run size annually entering the Columbia River from additional John Day generated smolts would leave roughly 70 to 140 thousand adults available to an annual terminal fishery. In comparison, existing hatchery production for John Day could produce, under optimum conditions, upward to 144 thousand fall chinook salmon for interception at terminal fisheries. Removal of available adults at these levels equates to very high harvest rates that can not be sustained under natural production conditions. Presumably, hatchery production in mitigation for inundation of the John Day reach would be continued at a decreasing level as natural production was restored, and would ultimately be replaced by restored natural production. Policies for abandoning hatchery production are unknown, therefore existing hatchery output is assumed to be constant. Under poor ocean conditions and high harvest rates, the modeled adult returns would be insufficient to replace the spawning population. The economic valuation results, therefore, should be considered as very liberal estimates for benefits from terminal fisheries of fall chinook originating in the John Day Dam pool area.

Fall chinook are the only considered anadromous fish species that have a significant ocean fishery in addition to terminal fisheries. Intercept rates vary with abundance levels, fishery management plans, and harvest allocations dictated by international and Indian treaties. The PATH process provided estimates of ocean fishery harvest rates (based on ocean escapement) from hydrosystem actions that restored the Columbia River reach behind the John Day Dam to natural river and the Snake River reach for the four lower Snake River dams to natural river. It was assumed the Snake River fall chinook harvest rate applies to fall chinook stocks behind the John Day Dam pool area improved from re-creating spawning habitat.

4.3. Harvestable Fish

Harvestable fish at maximum sustained yield population levels were provided over a range by Anderson et al. (1999). Point estimates were consistently selected from the many variables and

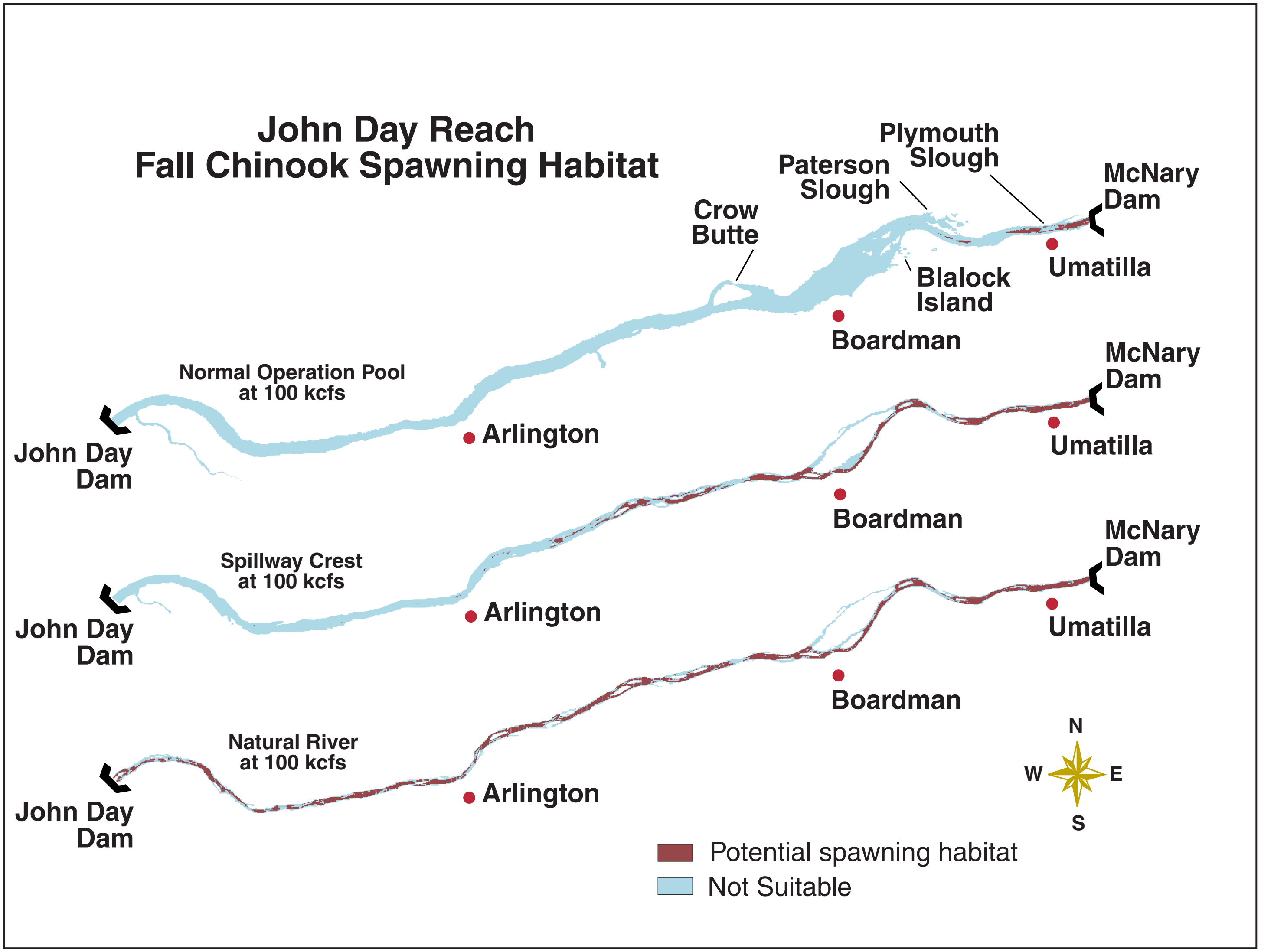


Figure 5. John Day Reach - Fall Chinook Spawning Habitat (from USGS 1999).

Table 6. Available Adults to Terminal Fisheries From Increased Habitat Capacity in the John Day Reservoir Under Various Drawdown Scenarios

	Spawner Capacity (#)	Smolt Yield (100 Smolts/Spawner)	Hydro System Survival	Potential Adult Returns	Fish Available to Fishery	
					Terminal	Ocean
Existing Conditions	5,500	550,000	314,500	16,100	10,600	2,737
Natural River	55,000	5,500,000	3,790,000	194,500	139,500	33,065
Spillway Crest	31,100	3,110,000	1,960,000	100,600	69,500	17,102

Note: Potential adult returns is ocean escapement.
Source: Willis (2000) and Study.

assumptions mentioned as contributing to the uncertainty in modeled results.[1] For example, using different values and assumptions (such as "D" values) for Snake River spring chinook gave results ranging from ± 50 percent for the effects from the natural river drawdown without flood control facilities alternative.[2] The substantial range means the harvest forecasts in this report should not necessarily be used to represent actual harvests or actual economic values that would occur if the dam alterations occurred. However, the comparisons of the alternatives to each other should be valid.

The forecasted harvestable fish distributed to user groups and fisheries resulting from John Day Dam alternative water management actions is provided in

Table 7 to Table 10. The tables include harvests from all affected wild and hatchery origin stocks.

Each affected stock will respond differently to altering the existing water management. For example, Hanford Reach fall chinook benefit from smolt transporting. Removing barging

1. The results are highly variable depending upon the assumptions for: 1) smolt survival rates, 2) D levels (i.e., differential mortality between transported and non-transported juvenile migrants related to assumptions regarding the effects of transportation on fish survival), 3) extra mortality factors (i.e., assumptions regarding effects of hatchery-related bacterial kidney disease, ocean climate regime shifts, or cumulative hydro-system stresses), and 4) adult survival rates (Anderson et al. 1999).
2. The current levels using the most recent 10 year average of Snake River spring chinook runs (ocean escapement, wild and hatchery origin, harvest plus spawners) are about 29 thousand (TAC 1997) with in-river mortality and harvests resulting in about 60 percent reaching the Snake River. Historically, the runs were considerably larger. In the 1950's, annual spring chinook returns to the Snake River were over 100 thousand adults and in the 1960's they were about 60 thousand (Peters et al. 1999). The current inriver harvest rate based on ocean escapement is about 10 percent. The forecasted harvest component of equilibrium maximum sustained yields (expanded to account for all wild and hatchery stocks) selected from Anderson (1999) estimate for the natural river without flood control alternative is comparable to levels in the 1950's. This assumes fishery management will allow much higher harvest rates at greater abundances.

transport and other Columbia River navigation will adversely affect this stock. Other stocks' downstream passage mortality will improve, thereby increasing returning adult harvestable fish. Figure 6 shows an example modeled adult return response for Snake River wild spring chinook. The hydrosystem action being analyzed in this figure is when the John Day Dam and the four lower Snake River dams have been removed and no flood control facilities are provided at the John Day Dam. The survival responses shown in

Table 7 to Table 10 are a composite over all affected stocks.

Table 7. Harvest Forecast for Affected Stocks for the Base Case

	Harvest																			
					Washington								Columbia Basin Inland					Hatchery		
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	8,651	65	36,870	2,830	6,636	3,039	82	1	2,239	853	1	1	13,074	34,907	17,265	69,481	693	34,204	34,204	265,097
1	8,766	67	37,379	2,867	6,722	3,080	85	1	2,269	866	1	1	13,469	36,037	17,479	70,974	712	35,644	35,644	272,063
2	8,981	69	38,289	2,936	6,883	3,156	88	1	2,324	888	1	1	13,885	37,181	17,891	72,919	738	37,084	37,084	280,399
3	9,276	71	39,528	3,031	7,107	3,260	93	1	2,400	918	1	1	14,318	38,339	18,464	75,235	771	38,524	38,524	289,861
4	9,654	73	41,108	3,154	7,394	3,393	98	1	2,497	956	1	1	14,770	39,510	19,204	77,934	810	39,964	39,964	300,489
5	10,120	76	43,043	3,305	7,749	3,557	104	1	2,617	1,001	1	1	15,242	40,698	20,118	81,035	856	41,404	41,404	312,334
10	13,352	82	56,160	4,359	10,218	4,694	139	2	3,453	1,304	2	2	15,989	41,338	26,516	95,891	1,144	41,404	41,404	357,453
15	18,072	91	75,098	5,884	13,783	6,359	213	3	4,666	1,760	3	3	17,194	42,674	35,631	117,583	1,694	41,404	41,404	423,517
20	21,277	97	87,845	6,911	16,182	7,493	275	3	5,486	2,076	3	3	18,072	43,791	41,701	132,314	2,134	41,404	41,404	468,470
25	22,217	99	91,603	7,214	16,889	7,825	291	3	5,727	2,167	3	3	18,319	44,082	43,502	136,635	2,252	41,404	41,404	481,641
30	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
35	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
40	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
45	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
50	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
55	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
60	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
65	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
70	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
75	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
80	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
85	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
90	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
95	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729
100	22,367	99	92,208	7,263	17,003	7,878	293	3	5,765	2,181	3	3	18,354	44,115	43,796	137,322	2,266	41,404	41,404	483,729

Note: "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.
Source: Study.

Table 8. Harvest Forecast for Affected Stocks for the "Natural River" Alternative

	Harvest																				
					Washington								Columbia Basin Inland					Hatchery			
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	24,857	91	104,398	8,232	19,360	8,694	84	4	6,482	2,267	4	4	15,902	34,907	51,196	143,995	1,103	34,890	34,890	491,360
5	25,241	112	106,200	8,332	19,582	8,838	126	4	6,569	2,344	4	4	20,402	48,315	51,564	156,999	1,357	52,110	52,110	560,210
10	25,478	113	106,620	8,373	19,657	8,936	184	4	6,614	2,399	4	4	20,762	49,423	51,459	158,137	1,700	52,110	52,110	564,084
15	30,588	125	126,274	9,966	23,351	10,761	349	4	7,900	2,943	4	4	22,533	52,491	60,430	181,665	2,799	52,110	52,110	636,408
20	37,854	140	154,782	12,270	28,714	13,341	528	5	9,748	3,682	5	5	24,737	55,768	73,780	215,082	4,028	52,110	52,110	738,690
25	38,764	142	158,148	12,545	29,346	13,669	571	5	9,972	3,787	5	5	25,121	56,554	75,239	219,267	4,300	52,110	52,110	751,659
30	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
35	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
40	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
45	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
50	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
55	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
60	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
65	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
70	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
75	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
80	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
85	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
90	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
95	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053
100	37,997	141	154,920	12,287	28,737	13,403	574	5	9,771	3,722	5	5	25,006	56,619	73,598	215,744	4,301	52,110	52,110	741,053

Note: "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.
Source: Study.

Table 9. Harvest Forecast for Affected Stocks for the "Spillway Crest" Alternative

	Harvest																				
					Washington								Columbia Basin Inland					Hatchery			
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	24,857	91	104,398	8,232	19,360	8,694	84	4	6,482	2,267	4	4	15,902	34,907	51,196	143,995	1,103	34,890	34,890	491,360
5	24,700	108	103,903	8,155	19,166	8,648	121	4	6,429	2,291	4	4	19,648	46,325	50,484	152,825	1,313	49,636	49,636	543,398
10	24,202	108	101,313	7,955	18,675	8,488	173	3	6,283	2,279	3	3	19,844	47,310	48,896	150,561	1,607	49,636	49,636	536,977
15	26,846	115	110,913	8,741	20,477	9,446	316	4	6,931	2,594	4	4	21,056	49,933	52,941	162,724	2,510	49,636	49,636	574,825
20	30,947	124	126,555	10,011	23,416	10,915	462	4	7,960	3,038	4	4	22,536	52,608	60,002	181,580	3,470	49,636	49,636	632,907
25	31,113	125	126,895	10,043	23,479	10,982	497	4	7,992	3,073	4	4	22,751	53,258	59,980	182,344	3,682	49,636	49,636	635,498
30	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
35	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
40	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
45	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
50	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
55	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
60	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
65	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
70	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
75	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
80	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
85	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
90	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
95	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968
100	30,280	124	123,395	9,763	22,819	10,692	500	4	7,773	3,002	4	4	22,621	53,314	58,205	178,516	3,678	49,636	49,636	623,968

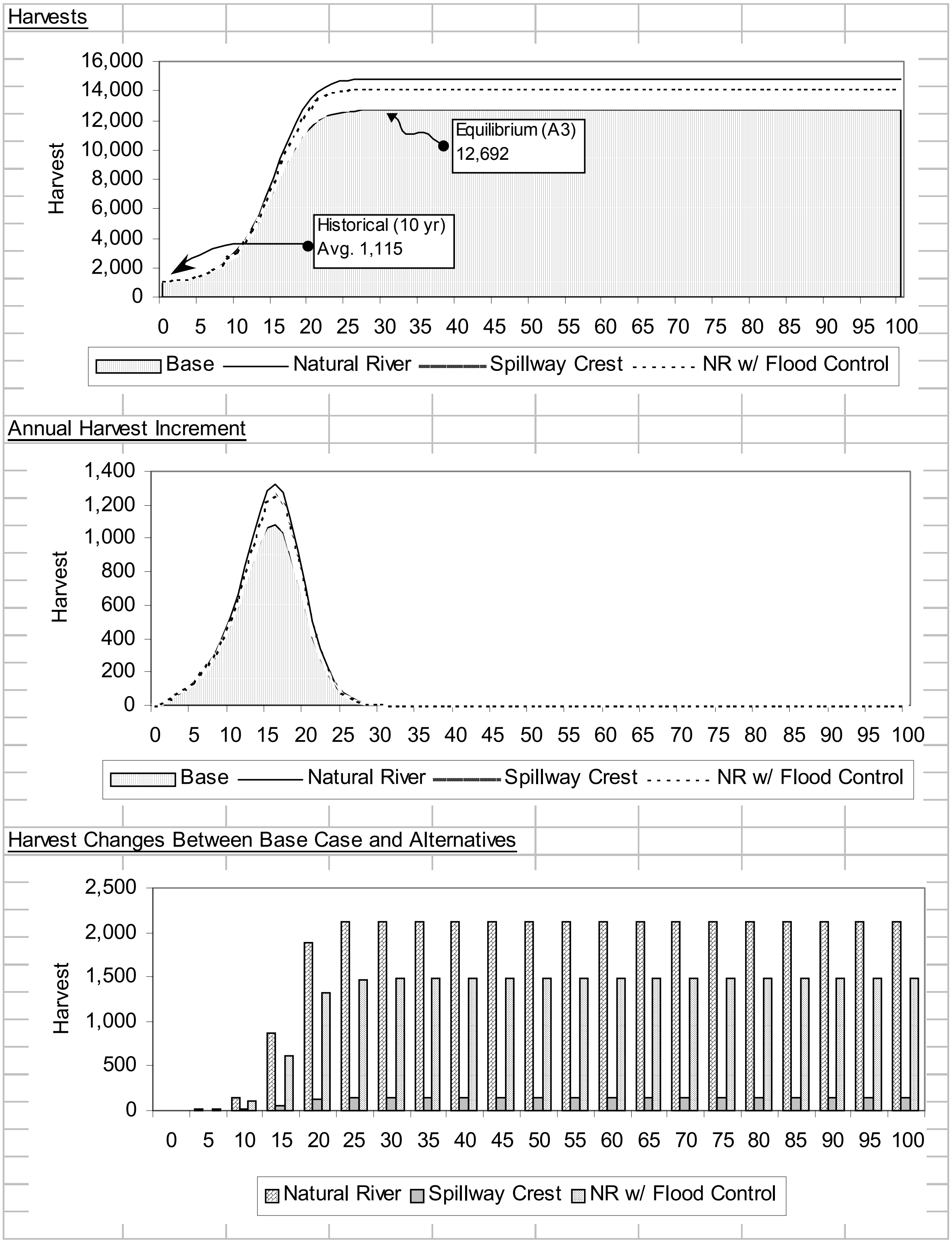
Note: "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.
Source: Study.

Table 10. Harvest Forecast for Affected Stocks for the "Natural River With Flood Control" Alternative

	Harvest																				
					Washington								Columbia Basin Inland					Hatchery			
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	24,857	91	104,398	8,232	19,360	8,694	84	4	6,482	2,267	4	4	15,902	34,907	51,196	143,995	1,103	34,890	34,890	491,360
5	25,232	111	106,149	8,330	19,578	8,835	124	4	6,568	2,342	4	4	20,178	47,643	51,564	156,390	1,347	51,293	51,293	556,987
10	25,460	112	106,549	8,369	19,650	8,928	180	4	6,610	2,394	4	4	20,522	48,703	51,459	157,473	1,679	51,293	51,293	560,686
15	30,532	123	126,119	9,955	23,329	10,738	338	4	7,889	2,930	4	4	22,241	51,618	60,430	180,814	2,732	51,293	51,293	632,391
20	37,745	138	154,510	12,248	28,670	13,297	506	5	9,726	3,659	5	5	24,378	54,689	73,780	213,977	3,896	51,293	51,293	733,822
25	38,642	140	157,850	12,520	29,297	13,621	547	5	9,948	3,761	5	5	24,746	55,428	75,239	218,104	4,154	51,293	51,293	746,599
30	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
35	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
40	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
45	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
50	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
55	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
60	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
65	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
70	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
75	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
80	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
85	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
90	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
95	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980
100	37,874	139	154,620	12,262	28,688	13,354	550	5	9,746	3,696	5	5	24,629	55,490	73,598	214,577	4,154	51,293	51,293	735,980

Note: "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.
Source: Study.

Figure 6. Harvest Forecast for an Example Affected Stock (Snake River Spring Chinook)



Notes: 1. Historical 10 year averages are used to represent Year 0 starting point.
2. Annual harvest increments are the five year differences.

Source: Study.

5. ECONOMIC VALUE FORECAST

Economic values for commercial fisheries are modeled as a direct calculation between distributed harvests and unit values in the geographic area where the harvest occurs. This can be functionally expressed as:

(Eq. 1) $$F_{a,w,y,l} = P \cdot O_{w,y,l}$$

where:

where:	P	=	Geographic harvest distribution matrix
	O	=	number of fish available for harvest at maximum sustainable yields in a forecast year for a particular alternative
	a	=	geographic harvest area
	w	=	wild and hatchery stocks
	y	=	forecast year
	l	=	hydrosystem alternative

(Eq. 2) $$K_{y,l} = \sum_{w,a} V_{w,a} \cdot F_{a,w,y,l}$$

where:	V	=	value per fish in a geographic harvest area for a particular specie
	F	=	harvest from Eq. 1
	K	=	economic value at one year for all affected stocks in all fisheries for a particular alternative

The economic values for recreational fisheries are similar, except forecasted success rates (angler days per fish) are a factor and the economic value is per angler day. The intermediate economic values in Equation 2 can then be summed over the project period and annualized.[1] The difference from the base case can then be compared to show ranking of alternatives. For example, the difference in coastal Washington recreational ocean fishery for Hanford Reach fall chinook after stocks reach equilibrium for the natural river alternative has the following calculation:

(140,659 - 214,640)	·	0.02514	·	$51.43	·	1	=	-$95,654
Table 5		Table 4		Table 3		Table 3		Table 11

This means there is a decrease of $95.6 thousand for this fishery after stocks reach equilibrium for the natural river without flood control facilities alternative. When all other analyzed stocks are included in the accounting, the change in the example fishery is an increase of $81 thousand (Table 11).

The changed annualized economic values from increased anadromous fish harvest resulting from John Day Dam water management alternatives ranges from $3.5 million (Action B1, or the natural river drawdown alternative) to $2.0 million (Action B2, the spillway crest alternative). Including flood control with the natural river alternative (Action B3) would lower the natural river alternative to $3.4 million (Table 11). The changed annualized

1. Annualized methods use the Corps definition for average annual equivalent value based on the current Corps discount rate of 6 7/8 percent.

economic values by fishery, by user groups, by stock origin, and by selected composite stocks contribution are shown in Figure 7 through Figure 10 respectively.

Table 11. Changed Annualized Economic Values From Alternative John Day Dam Hydrosystem Actions by Fishery

Fishery	B1 less A1	B2 less A1	B3 less A1
Commercial			
Ocean			
Alaska	$180	$77	$179
British Columbia	$708	$283	$704
WA Ocean	$92	$37	$91
WA Puget Sound	$3	$3	$3
Oregon	$29	$12	$29
California	$0	$0	$0
Subtotal Ocean	$1,012	$412	$1,006
Inriver			
Non-treaty	$223	$80	$223
Treaty Indian	$646	$305	$636
Hatchery Returns	$144	$120	$136
Subtotal Inriver	$1,012	$504	$995
Subtotal Commercial	$2,025	$917	$2,001
Recreational			
Ocean			
Alaska	$0	$0	$0
British Columbia	$78	$28	$78
WA Ocean	$81	$29	$81
WA Puget Sound	$0	$0	$0
Oregon	$20	$7	$20
California	$0	$0	$0
Subtotal Ocean	$179	$65	$179
Inriver			
Mainstem	$735	$546	$697
Tributary	$579	$474	$544
Subtotal Inriver	$1,314	$1,020	$1,240
Subtotal Recreational	$1,494	$1,084	$1,420
Total Commercial and Recreational	$3,518	$2,001	$3,421

Notes: 1. Economic values expressed as average annual equivalent values in thousands of 1998 dollars using a 6 7/8% discount rate.
2. Total and subtotals may not equal sum of values due to rounding.
Source: Study.

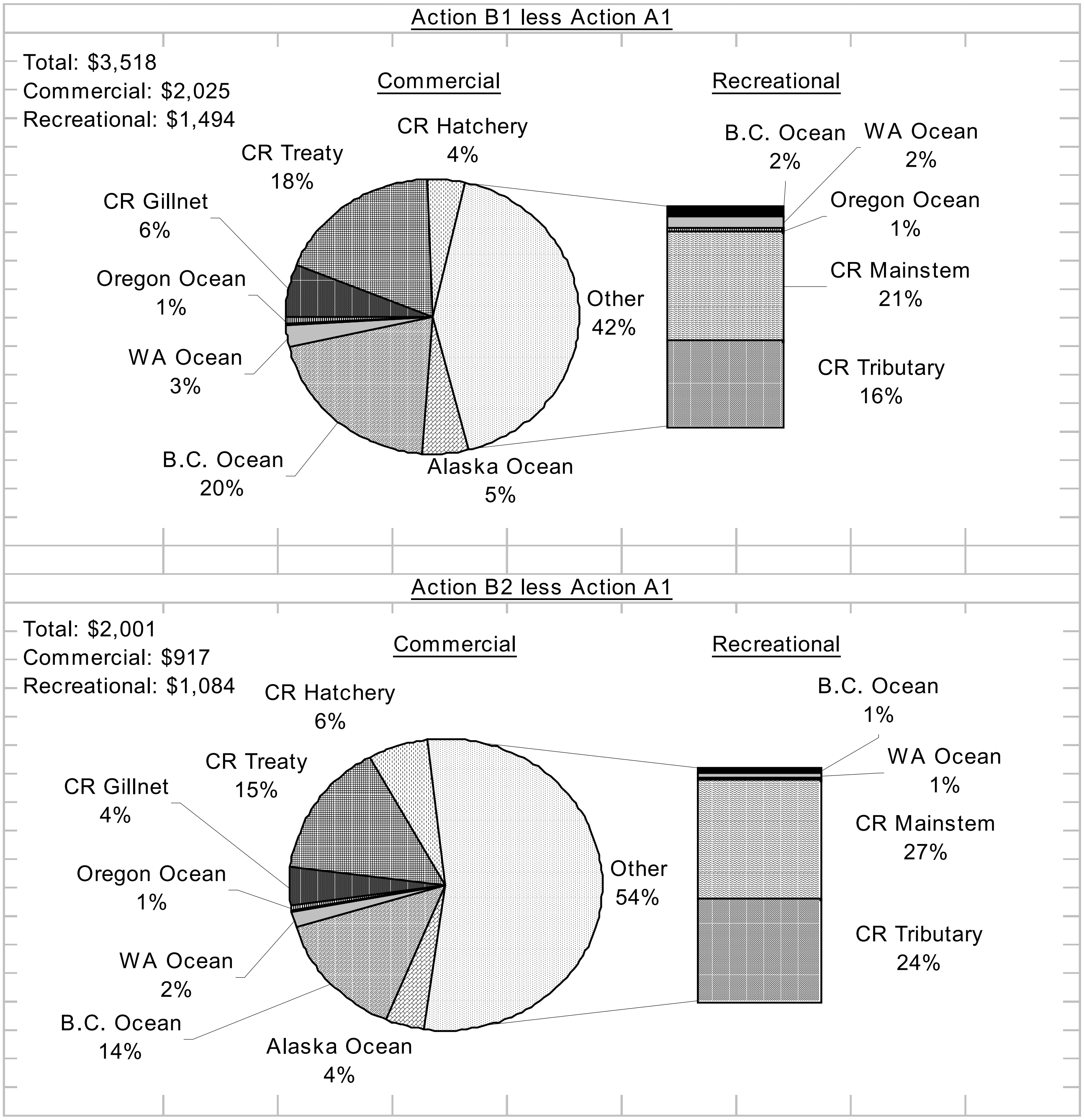
The economic values summarized by hatchery and wild stocks over the project period are graphically shown in Figure 11. Table 12 through

Table 15 show the economic values by fishery over the project period.

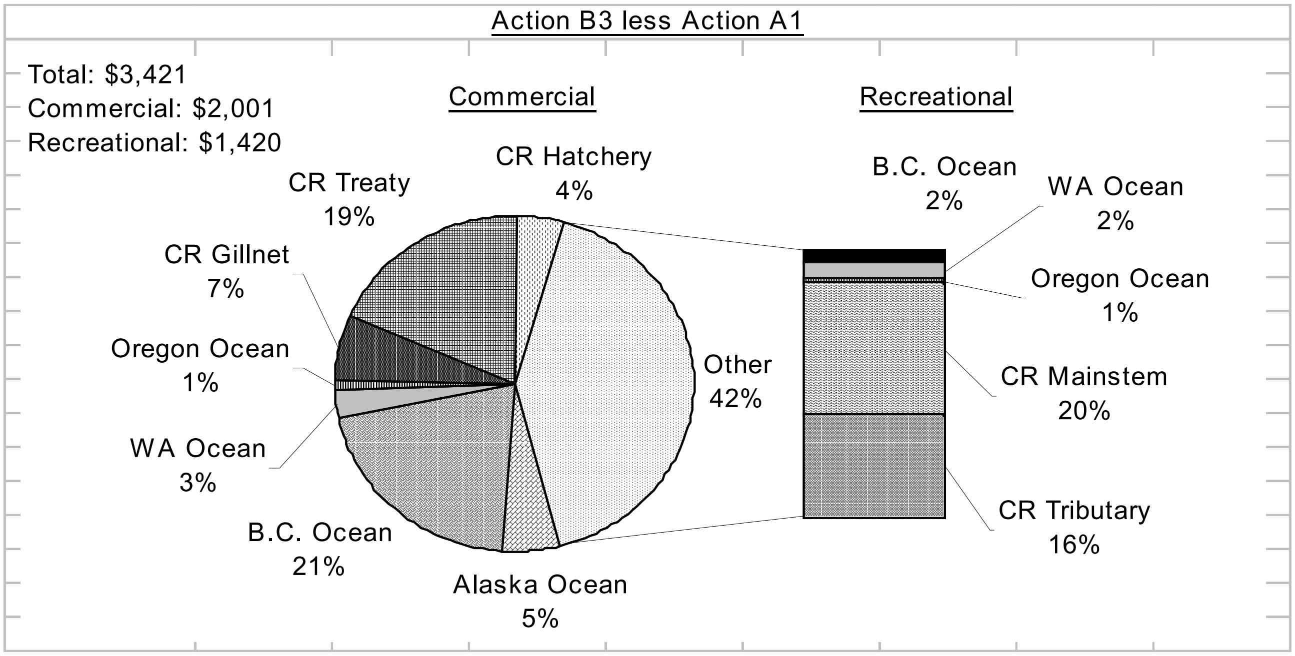
There is sensitivity of changed annualized economic values for a schedule of altering the John Day Dam and four lower Snake River dams. For example, Figure 12 shows the case of the John Day Dam being breached and the four lower Snake River dams being unaltered for selected composite stocks. Comparison of this example's alternatives with the alternatives where breaching occurs in tandem shows that benefits are about 20 percent of when breaching occurs together. Table 16 is a comparison of three cases for dam breaching schedule combinations.

Willis (2000) describes the wide differences in schedule combination results being attributable to smolt passage survival rate effects for determining total adult returns at maximum sustained yields. Altering the John Day Dam is assumed to curtail smolt transportation. If survival modeling assumptions emphasize effectiveness of transportation, then alterations are ineffective. Because the stocks negatively affected by curtailing transportation outnumber those that are unaffected, the resulting economic valuations will be negative. However, fall chinook produced from re-created habitat will always be a benefit from the alterations and ameliorate the plusses and minuses from transportation effects.

Figure 7. Changed Annualized Economic Value From Alternative John Day Dam Hydrosystem Actions by Fishery



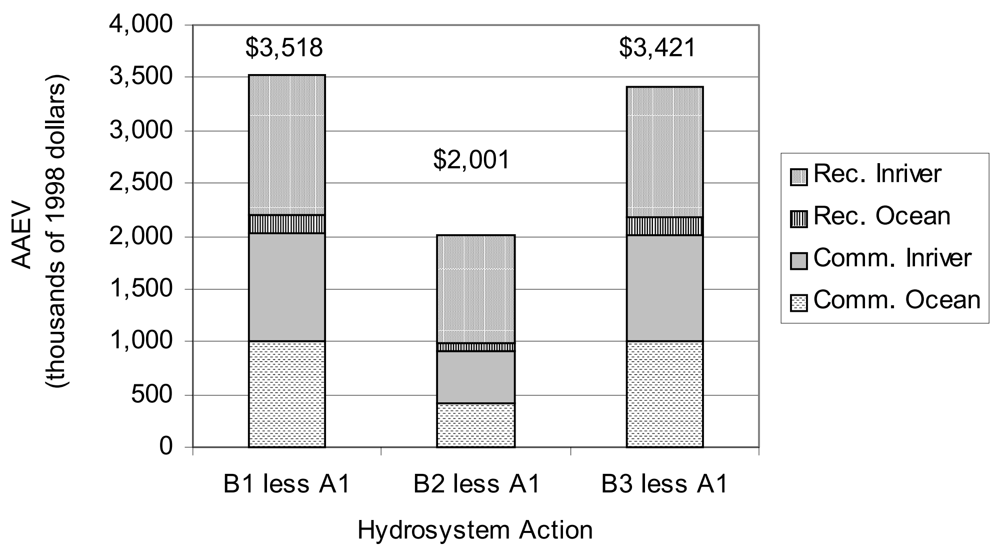
(continued)



Notes: 1. Economic values expressed as average annual equivalent values in thousands of 1998 dollars using a 6 7/8% discount rate.
2. Shares of less than 1% are not displayed for clarity.
3. CR refers to Columbia River.

Source: Study.

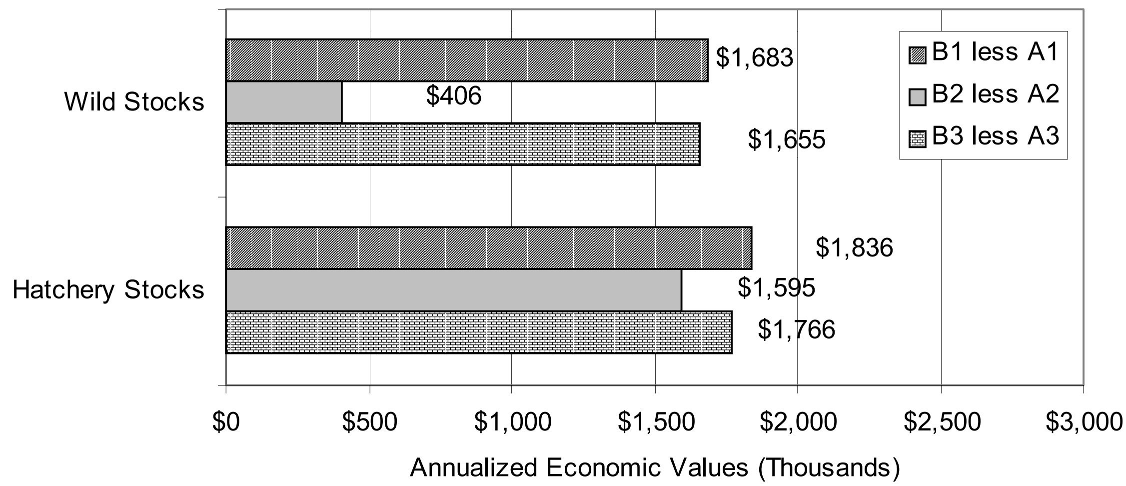
Figure 8. Changed Annualized Economic Values by User Group



Note: Economic values expressed as average annual equivalent values in thousands of 1998 dollars using a 6 7/8% discount rate.

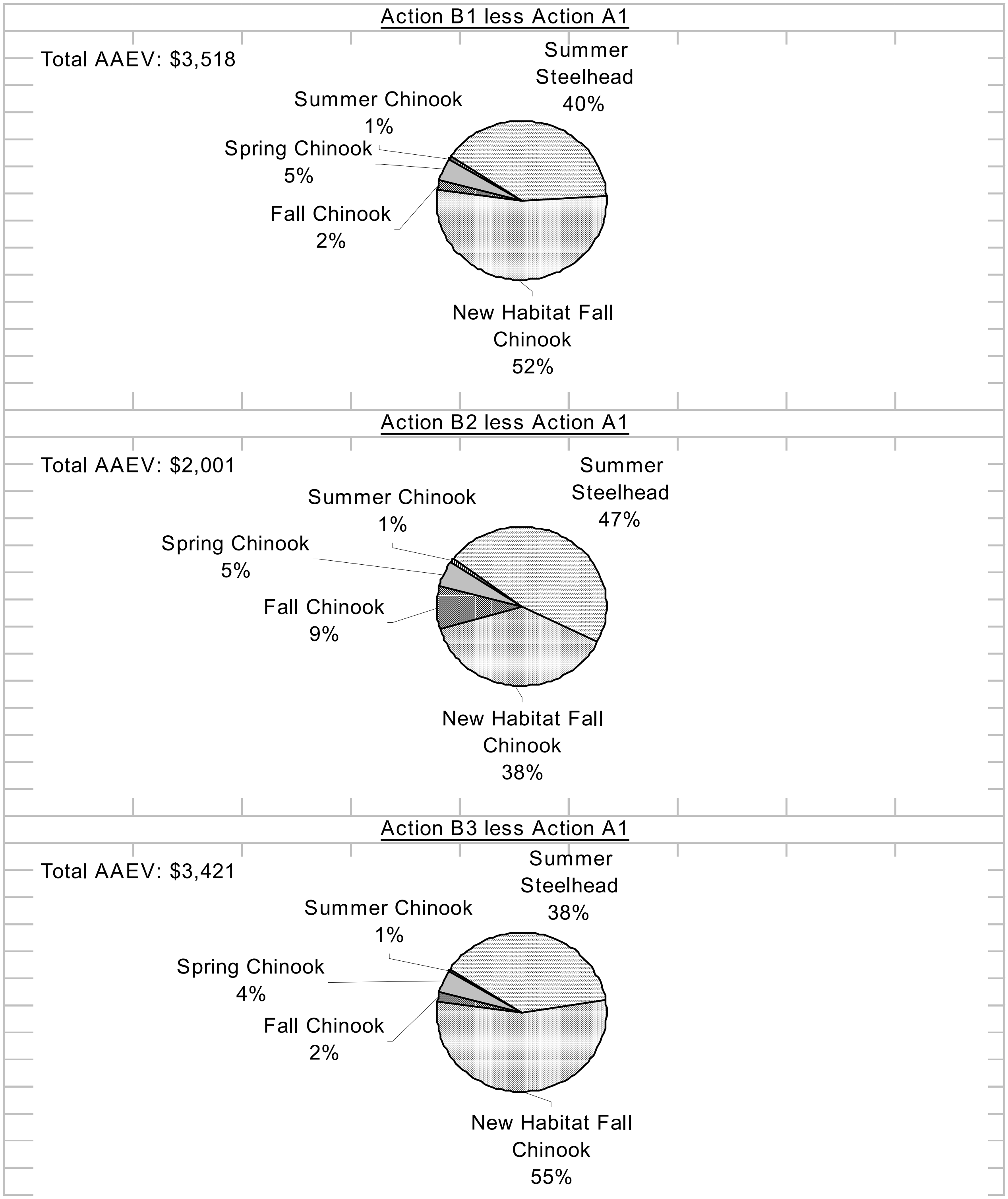
Source: Study.

Figure 9. Changed Annualized Economic Values by Stock Origin



Note: Economic values expressed as average annual equivalent values in thousands of 1998 dollars using a 6 7/8% discount rate.
Source: Study.

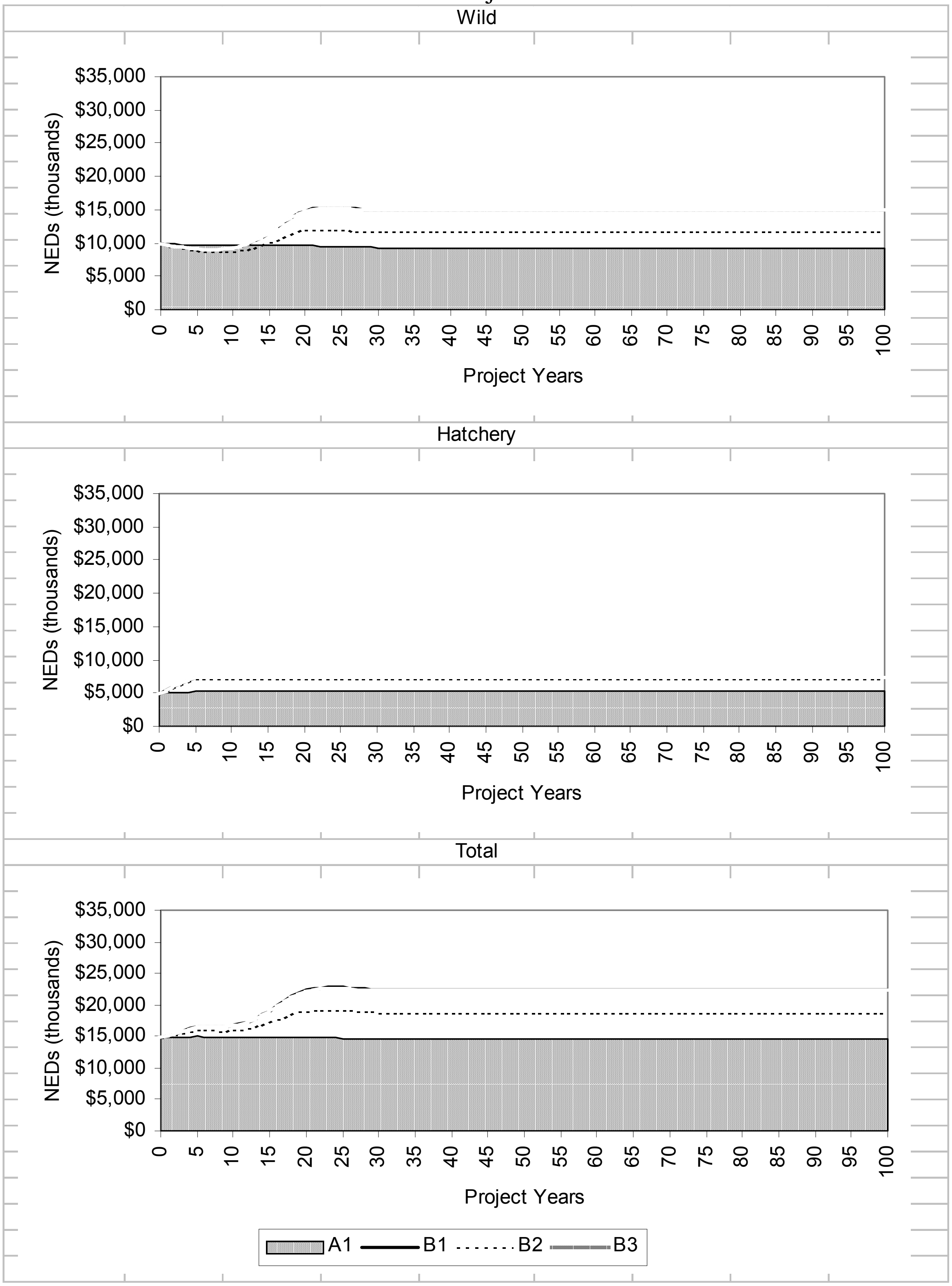
Figure 10. Changed Annualized Economic Values Contributed by Selected Composite Stocks



Notes: 1. Economic values expressed as average annual equivalent values in thousands of 1998 dollars using a 6 7/8% discount rate.
2. Shares of less than 1% are not displayed for clarity.

Source: Study.

Figure 11. Total Economic Value by Wild Origin and Hatchery Origin Anadromous Fish Over the Project Period



Note: Economic value in thousands of 1998 dollars.
Source: Study.

Table 12. Economic Values for the Base Case

	Economic Value																			
					Washington								Columbia Basin Inland					Hatchery		
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	292,650	686	1,225,752	141,373	157,144	147,980	1,739	62	48,484	37,026	27	62	2,066,800	1,743,599	406,248	1,229,022	0	319,333	40,967	7,858,956
1	296,569	694	1,241,936	143,128	159,175	149,817	1,797	63	49,123	37,486	28	63	2,129,255	1,800,023	411,290	1,251,025	0	335,023	42,549	8,049,043
2	303,817	711	1,271,880	146,498	162,997	153,345	1,872	65	50,313	38,368	28	65	2,195,042	1,857,200	420,974	1,283,632	0	350,712	44,132	8,281,650
3	313,793	733	1,313,100	151,191	168,287	158,257	1,963	67	51,956	39,598	29	67	2,263,582	1,915,015	434,460	1,324,934	0	366,401	45,714	8,549,145
4	326,598	763	1,365,988	157,251	175,096	164,600	2,070	69	54,068	41,185	30	69	2,335,012	1,973,532	451,874	1,375,245	0	382,090	47,296	8,852,835
5	342,352	799	1,431,025	164,731	183,486	172,430	2,196	73	56,668	43,144	32	73	2,409,513	2,032,845	473,369	1,434,949	0	397,779	48,878	9,194,340
10	451,687	1,053	1,880,215	217,123	241,970	227,271	2,951	96	74,749	56,866	42	96	2,525,644	2,064,856	623,924	1,782,974	0	397,779	48,878	10,598,173
15	611,364	1,415	2,528,309	291,761	326,382	305,397	4,517	129	101,008	76,414	56	129	2,713,420	2,131,570	838,401	2,290,233	0	397,779	48,878	12,667,161
20	719,802	1,656	2,964,281	341,463	383,183	357,422	5,825	151	118,765	89,431	66	151	2,850,465	2,187,340	981,224	2,634,186	0	397,779	48,878	14,082,066
25	751,608	1,728	3,092,866	356,209	399,933	372,857	6,167	157	123,986	93,293	69	157	2,889,044	2,201,919	1,023,598	2,735,164	0	397,779	48,878	14,495,410
30	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
35	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
40	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
45	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
50	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
55	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
60	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
65	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
70	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
75	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
80	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
85	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
90	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
95	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
100	756,664	1,739	3,113,579	358,618	402,630	375,379	6,205	158	124,821	93,924	69	158	2,894,546	2,203,545	1,030,520	2,751,250	0	397,779	48,878	14,560,462
NPV	$7,323,903	$16,964	$30,346,240	$3,497,715	$3,911,278	$3,661,189	$53,489	$1,542	$1,210,238	$916,068	$676	$1,542	$36,975,391	$29,756,031	$10,050,999	$28,192,547	$0	$5,576,660	$689,702	$162,182,175
AAEV	$504,171	$1,168	$2,089,010	$240,780	$269,249	$252,033	$3,682	$106	$83,312	$63,061	$47	$106	$2,545,355	$2,048,380	$691,902	$1,940,752	$0	$383,893	$47,478	$11,164,486

Notes: 1. Economic values are in thousands of 1998 dollars.
2. "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.

Source: Study.

Table 13. Economic Values for the "Natural River" Alternative

	Economic Value																			
					Washington								Columbia Basin Inland					Hatchery		
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	840,919	2,033	3,541,946	419,208	458,454	438,801	1,790	185	140,328	109,793	81	185	2,503,031	1,743,599	1,204,633	2,982,330	0	331,864	41,812	14,760,991
5	853,902	2,048	3,588,815	422,222	463,692	441,956	2,672	186	142,225	110,582	82	186	3,216,382	2,413,336	1,213,293	3,134,259	0	522,184	60,812	16,588,833
10	861,925	2,044	3,601,995	421,367	465,483	441,060	3,889	186	143,186	110,358	81	186	3,273,583	2,468,667	1,210,835	3,157,814	0	522,184	60,812	16,745,654
15	1,034,801	2,400	4,272,706	494,823	552,962	517,949	7,403	218	171,044	129,596	96	218	3,551,099	2,621,950	1,421,917	3,703,583	0	522,184	60,812	19,065,761
20	1,280,616	2,930	5,246,899	604,141	679,940	632,377	11,194	266	211,036	158,227	117	266	3,895,903	2,785,610	1,736,053	4,481,780	0	522,184	60,812	22,310,351
25	1,311,370	2,988	5,361,474	616,084	694,904	644,878	12,097	272	215,904	161,355	119	272	3,956,190	2,824,868	1,770,372	4,578,273	0	522,184	60,812	22,734,414
30	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
35	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
40	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
45	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
50	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
55	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
60	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
65	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
70	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
75	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
80	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
85	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
90	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
95	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
100	1,285,433	2,923	5,250,674	602,649	680,495	630,815	12,167	266	211,536	157,837	116	266	3,938,516	2,828,100	1,731,765	4,495,196	0	522,184	60,812	22,411,747
NPV	$14,578,713	$34,136	$60,471,073	$7,038,314	$7,826,031	$7,367,265	$87,718	$3,103	$2,414,965	$1,843,368	$1,359	$3,103	$48,694,451	$35,577,966	$20,225,228	$52,098,290	$0	$7,095,629	$834,491	$266,195,204
AAEV	$1,003,587	$2,350	$4,162,779	$484,512	$538,737	$507,156	$6,038	$214	$166,244	$126,896	$94	$214	$3,352,086	$2,449,158	$1,392,288	$3,586,403	$0	$488,457	$57,446	$18,324,657

Notes: 1. Economic values are in thousands of 1998 dollars.
2. "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.

Source: Study.

Table 14. Economic Values for the "Spillway Crest" Alternative

	Economic Value																			
					Washington								Columbia Basin Inland					Hatchery		
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	840,919	2,033	3,541,946	419,208	458,454	438,801	1,790	185	140,328	109,793	81	185	2,503,031	1,743,599	1,204,633	2,982,330	0	331,864	41,812	14,760,991
5	835,585	2,005	3,512,246	413,383	453,862	432,703	2,561	182	139,191	108,267	80	182	3,097,338	2,313,940	1,187,893	3,059,089	0	495,579	58,084	16,112,171
10	818,765	1,942	3,422,325	400,381	442,235	419,094	3,666	177	136,025	104,862	77	177	3,128,966	2,363,127	1,150,531	3,003,180	0	495,579	58,084	15,949,192
15	908,184	2,103	3,748,700	433,503	484,890	453,763	6,688	191	150,055	113,536	84	191	3,319,604	2,494,153	1,245,709	3,282,852	0	495,579	58,084	17,197,870
20	1,046,942	2,383	4,282,215	491,321	554,498	514,284	9,790	217	172,327	128,679	95	217	3,551,740	2,627,752	1,411,855	3,720,022	0	495,579	58,084	19,067,999
25	1,052,558	2,382	4,293,167	491,136	555,971	514,091	10,540	217	173,032	128,631	95	217	3,585,824	2,660,240	1,411,324	3,736,405	0	495,579	58,084	19,169,491
30	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
35	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
40	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
45	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
50	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
55	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
60	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
65	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
70	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
75	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
80	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
85	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
90	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
95	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
100	1,024,383	2,312	4,173,058	476,601	540,351	498,876	10,601	210	168,292	124,824	92	210	3,565,974	2,663,048	1,369,557	3,646,181	0	495,579	58,084	18,818,234
NPV	$13,086,997	$30,640	$54,303,582	$6,317,318	$7,024,821	$6,612,572	$78,946	$2,785	$2,167,798	$1,654,536	$1,220	$2,785	$45,945,352	$34,049,638	$18,153,382	$47,140,979	$0	$6,777,697	$801,890	$244,152,938
AAEV	$900,898	$2,109	$3,738,214	$434,879	$483,583	$455,204	$5,435	$192	$149,229	$113,897	$84	$192	$3,162,840	$2,343,949	$1,249,664	$3,245,146	$0	$466,571	$55,201	$16,807,286

Notes: 1. Economic values are in thousands of 1998 dollars.
2. "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.

Source: Study.

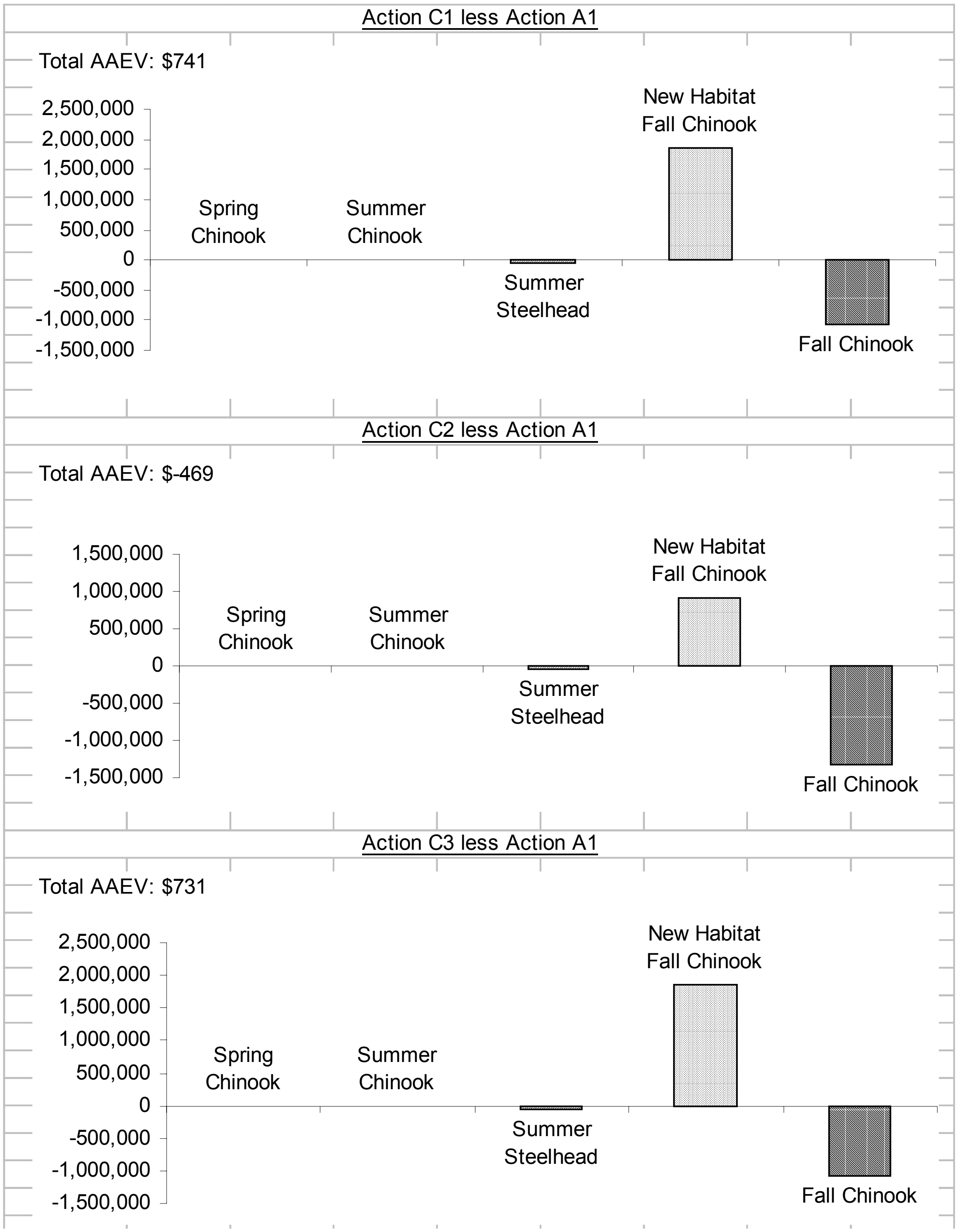
Table 15. Economic Values for the "Natural River With Flood Control" Alternative

	Economic Value																			
					Washington								Columbia Basin Inland					Hatchery		
Project	Alaska		British Columbia		Ocean		Puget Sound		Oregon		California		Recreational		Commercial			Egg &	Food	
Year	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	MS	Trib	Gillnet	Tribal	Other	Carcass	Fish	Total
0	840,919	2,033	3,541,946	419,208	458,454	438,801	1,790	185	140,328	109,793	81	185	2,503,031	1,743,599	1,204,633	2,982,330	0	331,864	41,812	14,760,991
5	853,604	2,048	3,587,837	422,222	463,609	441,956	2,635	186	142,187	110,582	82	186	3,180,880	2,379,781	1,213,293	3,127,708	0	513,538	59,911	16,502,244
10	861,317	2,044	3,600,363	421,367	465,313	441,060	3,813	186	143,108	110,358	81	186	3,235,527	2,432,699	1,210,835	3,150,225	0	513,538	59,911	16,651,931
15	1,032,913	2,400	4,268,389	494,823	552,433	517,949	7,166	218	170,803	129,596	96	218	3,504,930	2,578,314	1,421,917	3,692,109	0	513,538	59,911	18,947,723
20	1,276,908	2,930	5,238,775	604,141	678,902	632,377	10,729	266	210,561	158,227	117	266	3,838,898	2,731,734	1,736,053	4,464,901	0	513,538	59,911	22,159,233
25	1,307,253	2,988	5,352,496	616,084	693,751	644,878	11,581	272	215,376	161,355	119	272	3,896,704	2,768,645	1,770,372	4,560,172	0	513,538	59,911	22,575,766
30	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
35	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
40	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
45	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
50	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
55	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
60	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
65	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
70	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
75	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
80	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
85	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
90	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
95	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
100	1,281,292	2,923	5,241,646	602,649	679,335	630,815	11,648	266	211,006	157,837	116	266	3,878,860	2,771,718	1,731,765	4,477,020	0	513,538	59,911	22,252,609
NPV	$14,555,476	$34,136	$60,418,139	$7,038,314	$7,819,526	$7,367,265	$84,805	$3,103	$2,411,989	$1,843,368	$1,359	$3,103	$48,143,869	$35,057,595	$20,225,228	$51,960,038	$0	$6,992,310	$823,725	$264,783,349
AAEV	$1,001,987	$2,350	$4,159,135	$484,512	$538,290	$507,156	$5,838	$214	$166,039	$126,896	$94	$214	$3,314,184	$2,413,336	$1,392,288	$3,576,886	$0	$481,345	$56,705	$18,227,466

Notes: 1. Economic values are in thousands of 1998 dollars.
2. "Comm" refers to commercial, "sport" refers to recreational angling, "MS" refers to mainstem, and "Trib" refers to tributary harvest.

Source: Study.

Figure 12. Changed Annualized Economic Values for Altering the John Day Dam Without Altering the Four Lower Snake River Dams



Notes: 1. Economic values expressed as average annual equivalent values in thousands of 1998 dollars using a 6 7/8% discount rate.

2. Actions referred to as "C" are synonymous with actions referred to as "B," but without breaching the four lower Snake River Dams.

Source: Study.

Table 16. Changed Annualized Economic Values From Three Schedule Combinations for Altering the John Day Dam and the Four Lower Snake River Dams

Schedule	Annualized Difference Between Actions: Natural River Less Base Case	Spillway Crest Less Base Case	Natural River With Flood Control Less Base Case
1. John Day Dam and four lower Snake River dams occur in tandem	3.52	2.00	3.42
2. John Day Dam without four lower Snake River dams	0.74	-0.47	0.73
3. Four lower Snake River dams breached without John Day Dam alterations	2.50	2.50	2.50

Notes: 1. Economic values expressed as average annual equivalent values in millions of 1998 dollars using a 6 7/8% discount rate.
2. The case of altering the four lower Snake River dams without altering the John Day Dam is shown for comparison purposes. The estimate may be different than in other current studies, such as the Lower Snake River Juvenile Salmon Migration Feasibility Study, due to different methods and assumptions. Different methods and data are used, so the estimate should not be used for evaluation of other study results.
3. Cumulative effects invalidate Schedule 2 and 3 summarizing to Schedule 1.

Source: Study.

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Attachment

Attachment A

Overview of Anadromous Fish Produced in the Columbia River Basin

Attachment B

Economic Evaluation Methods

Attachment C

John Day Dam Anadromous Fish Mitigation History

ATTACHMENT A

OVERVIEW OF ANADROMOUS FISH PRODUCED IN THE COLUMBIA RIVER BASIN

CHAPTER I. CHANGING PATTERN OF SALMON PRODUCTION

A. Historic Salmon Runs

To the Indians living along the Columbia River, salmon were their lifeblood, essential to their subsistence, their culture, and their religion. A focal point of this great salmon fishery for many centuries was Wy-am, one of the longest continuously occupied sites on the North American continent. Located near Celilo Falls on the Columbia River, the Wy-am area, before the Dalles Dam in 1957, was a commercial center during the fishing season. In autumn, as many as 5,000 people would gather to trade, feast, and participate in games and religious ceremonies. Here at salmon time were Indian goods to be traded for the prized dried salmon from half the continent. On hand were traders and goods, such as abalone shells and Wampum beads from California tribes, horses from the Nez Perce and Cayuse, slaves and dried clam meat from the chinook, and buffalo robes and native tobaccos from the plains tribes of the Rockies (Spranger and Anderson 1988).

The abundance of salmon astonished Lewis and Clark when they first explored the region in 1805 and 1806. Many of the earliest accounts of the fishery were detailed in the diaries of these early explorers. They refer to the "stinking river," a sweet rotting smell that came from the salmon carcasses along the banks of the Columbia.

Before Oregon became a state, fishing played an important part in the economy. As early as 1828, various trading companies were purchasing and exporting salmon caught by the Indians on the Columbia River. The first commercial use of fishery products in Oregon was the packing of salmon. Development of the canning process in the mid 1800's created a huge demand for salmon. Scandinavian and French immigrants worked with gillnets, beach seines, and fish wheels to harvest the abundant fish. The lower Columbia became the West Coast center of the packing industry (West Coast Fisheries Development Foundation 1986). Smaller canning projects developed on the coastal river systems, like the Umpqua.

In the 1860's, the process of canning salmon was perfected, permitting the fish to be transported over long distances, stored for extended periods, and kept palatable for consumers. By the 1880's, as many as 55 canneries were operating on or near the Columbia. In 1883 a total of 43 million pounds of chinook was harvested (Spranger and Anderson 1988). At this time, only the valuable chinook salmon was canned. The other species, coho, sockeye, and chum, as well as steelhead were not utilized by the canners.

As the 1893 Commissioner's Report states, "In the early years of the salmon-packing business on the Columbia chinook salmon were extremely abundant, comprising the bulk of the run and the pack; other varieties were unutilized. With the beginning of a decrease in the abundance of chinook salmon the small blueback salmon (sockeye) was brought more into notice . . . up to a comparatively recent date the steelhead, which has always occurred abundantly in the Columbia, was considered wholly unsuitable for packing. The same cause, however, which brought the blueback into use has led to the utilization of the steelhead. Recently the demand for canned salmon in certain sections of the country has called for a cheaper grade of fish, which has brought the neglected steelhead into prominence. The silver salmon, which does not enter the river until most of the canneries are closed, has also been canned in some quantities, and both it and steelhead have met with a ready sale that has yearly shown tendencies to greatly increase." (United States Commission of Fish and Fisheries 1895, pp.240-241).

The total harvested pounds of salmon and steelhead in the early 1890's ranged from 21 million pounds to 33 millions pounds. Chinook were generally about $1.00 per fish (in those years' prices), with other fish priced from $0.10 to $0.25 each. In the early 1890's the ex-vessel values were about $1 million. At today's prices, the ex-vessel value of these landings would be about $80 to $90 million.

In the late 1880's and early 1890's, the salmon canning industry was developing in Alaska. This and a nationwide general recession resulted in downward pressures on Columbia River harvested salmon prices. "For several years prior to 1880 the men had been receiving $1.00 each for chinook salmon . . . The men demanded $1.25 each for their fish, which, being refused, a general strike was begun which lasted throughout the month of April. After losing one month of the short salmon season, the men agreed to the price first offered . . . One dollar per fish was paid up to June 1, after which the canneries would give only $0.75 for chinooks." (United States Commission of Fish and Fisheries 1895, p.241).

In more recent times, the Columbia River produced around 20 million pounds until the late 1940's. Since then, the total poundage harvested commercially generally declined to the very low level in 1993, when a total of just over one million pounds of salmon was harvested in the Columbia River (Radtke and Davis, August 1994). As fish numbers have declined, so have the revenues received by fishermen.

Estimates of "pre-development" salmon run size depend on historical catch records and in some cases historic habitat availability. The Northwest Power Planning Council (NPPC), in order to assess the salmon and steelhead loses attributable to hydropower development and operations, developed estimates of "pre-European development" run sizes (NPPC, p.1). They concluded that up to 16 million fish run size is probably the most reasonable estimate of Columbia River historic salmon and steelhead runs (see Table A-1) (NPPC, pp.14-17). At recent historical prices, the ex-vessel value of the pre-development salmon and steelhead runs, at a 50 percent exploitation rate, would be about $272 million for the Columbia River Basin (Table A-1).

B. Columbia River Basin Salmon Fisheries

Salmon has been a significant and recurring source of protein for Oregonians. The abundant salmon runs of the Columbia supported a great trading center at Wy-am (Celilo Falls near The Dalles) for the Pacific Northwest Indians. The Indians netted and speared salmon from platforms and racks as the fish labored to get over the falls.

The development of commercial salmon harvesting did not begin until the 1850's and 1860's when canning of salmon was developed. As the canning process was perfected, the number of fish harvesters and methods of harvesting increased.

Table A-1
Estimated Historic, Pre-Development Salmon and Steelhead Run Size of the Columbia River System and Resulting Annual Potential Ex-Vessel Revenues

Species	Total Number of Fish (thousands)	Average Weight per Fish in Pounds	Total Pounds (thousands)	Price	Ex-Vessel Revenues at 50% Harvest Rate (thousands)
Spring chinook	2,300	20	46,000	3.25	74,750
Summer chinook	4,600	20	92,000	3.25	149,500
Fall chinook	2,300	20	46,000	1.00	23,000
Coho	1,780	9.0	16,020	1.00	8,010
Sockeye	2,600	3.5	9,100	2.00	9,100
Chum	1,392	12	16,704	0.60	5,011
Steelhead	1,348	8.5	11,458	0.60	3,437
Total	16,320		237,282		272,808

Notes:
1. Total number of fish from: NPPC (1986), pp.18-19.
2. Price is representative price per pound. These represent recent years prices for salmon harvested in the Columbia River. In the world salmon market, regional salmon production should be considered a commodity. Spring and summer chinook having timing and quality characteristics that command attractive prices.
3. Ex-vessel revenues at 50 percent harvest rate in most years with healthy stocks is considered a sustainable harvest rate.

Source: Radtke and Davis (January 1996, p. C-28).

Most fish were caught with gillnets, which entangle the fish. On the lower Columbia, trap nets and purse seines were used to catch salmon. The fish entered the trap nets through a narrow opening and, unable to find their way out, were stranded at low tide and taken out by dipnet. By the 1880's, horse drawn seines were used. The nets could harvest thousands of pounds of fish; in 1921, one net caught 60,000 pounds in one hour (Spranger and Anderson 1988). That calculates to 3,000 fish or about $3,000 of revenue. In these years, for an average worker, $1,000 per year was considered a lucrative income for one person.

Fish wheels were also used. Strategically located in the pathways of migrating salmon, the fish wheels used the swift river current to catch and deposit the fish into boxes. By 1899, 76 fish wheels were in operation on the Columbia River (Spranger and Anderson 1988). A fish wheel could average 100,000 pounds of salmon per year (or up to 6,000 fish).

In 1912, a few gillnet boats equipped with gasoline engines began to follow salmon into the ocean. By 1915, an estimated 500 boats were working off the mouth of the Columbia. By 1920, at least 1,000 trollers were operating out of a number of coastal ports. There were no seasonal restrictions on ocean fishing and markets demanded a more steady supply of salmon than the river fisheries could provide (West Coast Fisheries Development Foundation, 1986).

By 1943, the troll fishery hit an all-time low, with only 86,000 fish harvested. Fishery managers and legislators responded with increased gear restrictions, quotas, and increased hatchery construction.

As the salmon runs began to decline, the fishermen battled for their share. Each gear group claimed that its method of fishing was less harmful to the salmon runs than its competitor's. For example, fish wheels were outlawed in Oregon in 1926; seines were outlawed on the Columbia River in 1950. Gillnetting in all Oregon rivers except the Columbia was also eliminated in the 1950's. Today, troll fishing in the ocean, gillnetting on the Columbia, Indian gillnetting on the Columbia, and sport fishing in the Columbia and Oregon coastal rivers as well as open ocean are allowed under seasonal regulations.

During their life cycle, salmon range over a large and diverse land and seascape. De facto harvests of salmon can take place by not allowing the salmon cycle to be completed. Overharvesting by the early commercial fishing fleet took its toll on salmon abundance. Dams, urban development, and land management activities also restricted the salmon cycle and reduced the region's capacity to produce harvestable salmon. As restrictions on gear and geographic areas took place, fishing activity on Columbia River Basin produced fish developed in ocean waters off Oregon, Washington, California, British Columbia and Alaska. Some of these fisheries specifically target on Columbia River Basin produced fish; others harvest fish incidentally to targeting other salmon species. Other fisheries catch salmon incidentally to other marine species and most are discarded dead at sea.

C. Salmon Markets, Artificial Propagation, and Changing Harvests

1. Changing Salmon Markets[1]

In the past, the Sacramento River and the coastal areas of Washington, Oregon, and California were important for salmon production. The first canning operations in the western United States developed close to population centers in California. As the stocks of the Sacramento River were fished down, the California rivers polluted by the impact of gold miners, and as methods of canning were being developed, the Columbia River fish became attractive alternatives. At the peak, in 1883, nearly 630,000 cases of chinook were canned on the Columbia River (Cone 1995, p.107). This translates roughly to about 40 million pounds of gross weight or abut 2.0 million chinook salmon at 20 pounds average. This does not include the wasted salmon, due to congestion at the packing plants, etc. As was reported in oral history, "Every other night there would be them fish, beautiful big salmon, all washed and cleaned and ready . . . Then we would just have to go out and shovel them, often by the hundreds, back into the river (Cone 1995, p.115).

As canning and transportation methods advanced, the major West Coast salmon processing moved northward to Alaska. As for the Columbia, the declining abundance received another technological answer. Mr. W. A. Wilcox, an agent of the U. S. Fish Commission, who visited Portland on his regular tour of inspection of the region's fisheries, commented to the Oregonian in 1896, "The vast volume of fresh water coming down the Columbia will make it almost impossible ever to pollute it sufficiently to drive away the salmon, and it is hardly possible that civilization will ever crowd its banks to an extent that will endanger that [salmon

1. Much of this section is from Radtke and Davis (January 1996, p. A-4).

industry], so I suppose it is safe to say that Columbia River salmon will always continue to be a choice dish in all parts of the world . . . of course, the increased demand for fish and the growing scarcity of the same will call for more aid toward artificial propagation in order to keep up the supply." (Cone 1995, p.114).

The dam building period of the mid 1900's may not have affected the water purity, but it did affect the historical water flow with which specific species of salmon had evolved. The mix of salmon species and the timing of the runs were altered to the detriment of the Columbia River product. Instead of producing the bulk of salmon at the first of the season (spring chinook), the Columbia River fish now being produced were in greater competition with the salmon harvests in Alaska. The spring chinook that was traditionally harvested in the spring and summer is of high quality destined for specific markets. The change to late summer and fall harvests of fall chinook and other salmon species produced fish of lower quality and species that were also harvested in great quantities in other areas of the West Coast.

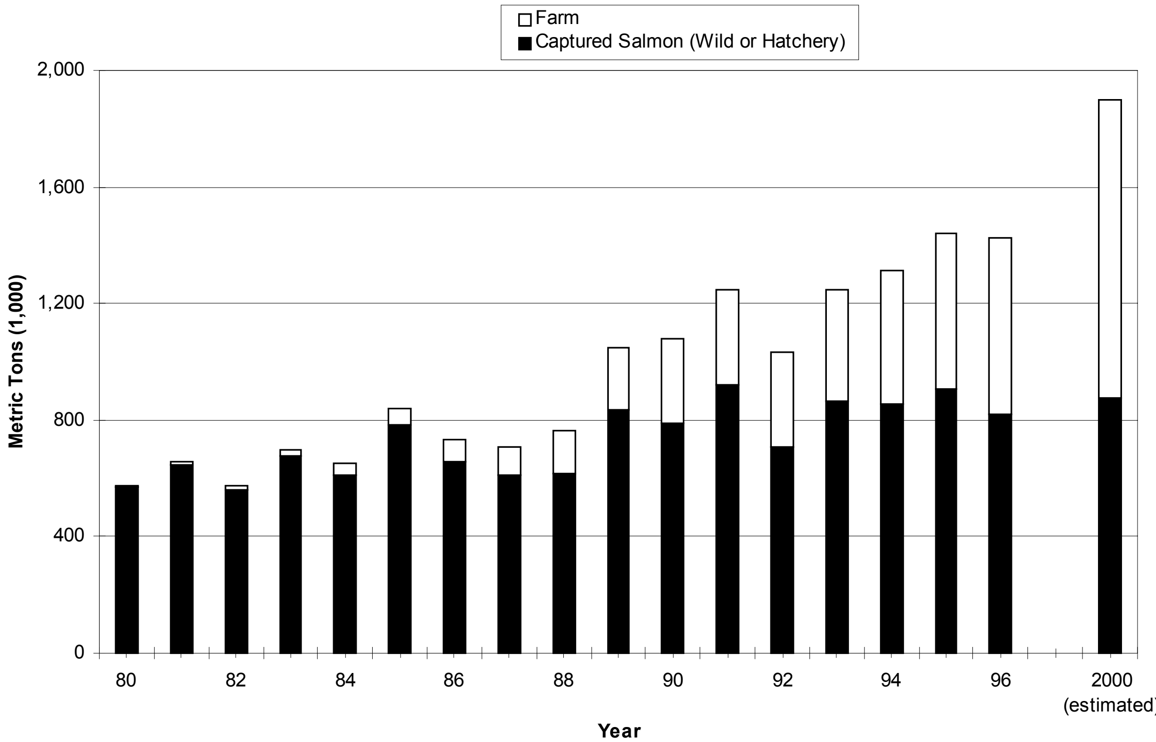
Salmon processing made great progress in the first sixty years after the first salmon cannery was built, but there was relatively little change in canning technology in the early 1900's. Canneries face two extremes of durability in their two principal markets: in their buying market they are faced with a highly perishable product and in their selling market a very durable one (Rubinstein 1966, p.18).

By 1888, a method of freezing was developed (Rubinstein 1966, p.17). As a direct method of presentation, it greatly increased the marketing capability of salmon, especially the highly desired chinook and sockeye species. In the last decade, as the use of ice and chilled seawater in harvesting boats, in tenders, and in processing is more common, marketing of fresh and quality frozen fish has dramatically improved. Coupled with speedier transportation systems, fresh and quality frozen fish are being shipped from any production area to markets throughout the world in a very short time. The new preservation and transportation methods improved the opportunities to market Columbia River fish throughout the world.

Since the early 1980's, improved captive salmon propagation procedures and transportation systems have allowed salmon aquaculture to supply the needs of the world market with a consistent supply of salmon. Salmon aquaculture, with its promise of consistent supply, is setting standards that have to be addressed by any other producers of salmon.

The world supply of salmon is going through dramatic changes. Captured salmon production has increased from about 600 thousand metric tons (mt) in 1980 to over 800 thousand mt in 1996. At the same time that captured salmon production increased, farmed salmon increased from no production in 1980 to over 700 thousand mt in 1996. Salmon supplies that were traditionally dependent on commercial harvests are changing toward farmed salmon production. Today's global salmon markets are characterized by strong competition and rapidly growing supplies of cultured product. Between 1980 and 1995, annual harvests of wild and farmed salmon increased from less than 600 thousand mt to over 1.4 million mt. Growth in total salmon production is forecast to continue, reaching over 1.8 million mt by the year 2000 (Figure A-1). Farmed salmon production is expected to increase to one half of total production within the next five to 10 years.

Figure A-1
World Salmon Supplies, 1980-2000



Source: Salmon Market Information Service (1995).

2. Changing Salmon Production

Salmon production may be described as coming from three sources. These are:

- Natural production
- Hatchery enhancement
- Farmed salmon

The U.S. and Canada have production from various levels in all of these sources. In the Sacramento-San Joaquin system, the commercial salmon harvest was as high as 12 million pounds (Western Water 1992). There was little control of this fishery, however, and over-fishing and industrial water based development caused a dramatic decline in salmon runs. Salmon hatcheries were established to mitigate for habitat destruction and for salmon run enhancement. The first California hatchery was established in 1872, the Baird Hatchery on the McCloud River. Today, almost all California chinook salmon production and about 70 to 75 percent of all Columbia River System salmon production is hatchery based (Washington Department of Fish and Wildlife (WDFW) and ODFW 1996).

As compensation for the loss of wild salmonid production, many artificial propagation hatcheries were built throughout the Columbia River Basin. Most of the salmon harvested on the west coast of North America come from Alaska waters. In Alaska, about 90 percent of all fish harvested are naturally produced fish (McNair and McGee 1994). Harvests in Alaska make up about 80 percent of all salmon harvested on the U.S.-Canada West Coast; therefore, about 75 to 85 percent of all salmon produced and harvested in the U.S. and Canada West Coast are naturally spawned.

Hatchery production may be used as a substitute for natural spawners. However, while commercial harvest may be increased significantly for some period, overall salmon production may also be decreased. Harvest rates based on the low number of returns necessary to seed another generation of hatchery fish can be too high to sustain natural production. Also, natural stock recruitment can be negatively affected by hatchery smolt releases (Anderson and Wilen 1985, pp.459-467), due primarily to natural selection process, competition for food, attraction of predators, and increased harvesting pressures. Basic, fundamental questions are being asked by scientists about the efficacy of hatchery programs and their effects on wild stocks. "It is now clear from synthesis of experience and from consideration of well-established biological knowledge that hatcheries have had demographic, ecological, and genetic impacts on wild salmon populations and have caused problems related to the behavior, health, and physiology of hatchery fish." (National Research Council 1996, pp.11-14).

Artificial salmon propagation in the Columbia River Basin was initiated in the late 1800's when managers realized that "…the increased demand for fish and the growing scarcity of the same will call for more aid toward artificial propagation in order to keep up the supply." (Cone 1995, p.114). Most of the early hatcheries were built for enhancement of salmon. As the waters of the Columbia River were used to develop the Pacific Northwest, artificial propagation was used to "mitigate" for the detrimental effects of the water projects.

Federal statutes such as the Federal Power Act and the Fish and Wildlife Coordination Act of 1934, were designed to provide mitigation for damage caused by water and other federal projects (WY-KAN-USH-MI WA-KISH-WIT 1995, pp.4-6). The Mitchell Act of 1938 is an example of these mitigation agreements. This Act funds a majority of mainstream Columbia River hatchery operations.

The Pacific Salmon Treaty (PST) between the United States and Canada also emphasized increased artificial propagation in order to satisfy allocation demands for salmon. And later, under the NPPC's goal of "doubling the salmon runs," the emphasis is also on increasing hatchery production.

The Endangered Species Act (ESA) has forced renewed emphasis on protecting natural runs and has changed the optimistic emphasis on artificial propagation. The changing survival rates of salmon in the ocean environment have shown that inriver survival rates may not be the limiting factor on any adult abundances available for harvest. The concern about certain species or sub-species of salmon, and the overall effect of hatchery fish on the survival of these species, has led to the NMFS placing a cap on the total hatchery releases in the Columbia River system.

The NMFS cap for smolt production from the Columbia River Basin at 197 million smolts (Table A-2) is to protect the salmon runs that have been declared threatened or endangered. The cap in effect requires reduction in smolt production and limits future growth of hatchery releases to those that have been identified as supplemental to wild production. "Supplementation is considered one of the major tools available to assist in rebuilding depressed Columbia River Basin salmon runs" (TAC 1997, p.6), with the caveat that "Ecological and genetic science suggests that artificial propagation must be carefully integrated into the functioning of the entire ecosystem." (Scientific Review Team 1999).

The early years of dam construction may have coincided with some very high survival rates of salmon smolts to harvestable adults. Survival rates for hatchery released coho were as high as eight percent in some of these years. They averaged about four percent in the 1980's, and are now less than one percent. Chinook survival rates, both fall and spring, have also decreased to fractions of what they had been in earlier years.

Table A-2
Annual Cap Smolt Production for Unlisted Species in the Columbia River Basin
Established in NMFS Proposed Recovery Plan, March 1995

Agency	Spring Chinook	Fall Chinook	Coho	Steelhead	Chum	Sockeye	Sea-Run Cutthroat	Total
Snake River								
BPA	454,700							454,700
COE				2,300,000				2,300,000
USFWS	5,532,816	800,000		6,351,000				12,683,816
IDFG	3,000,000			1,800,000				4,800,000
Snake River Total	8,987,516	800,000		10,451,000				20,238,516
Non-Snake River								
SFWS	3,975,000			400,000				4,375,000
NMFS	10,241,700	75,984,750	21,836,000	2,434,250			126,975	110,623,675
COE	6,968,000	10,380,000		507,500				17,855,500
BPA	1,290,000	2,700,000		150,000				4,140,000
BIA						150,000		150,000
ODFW	800,000	900,000	2,868,450	729,250			15,000	5,312,700
WDFW	7,014,500	14,909,500	9,700,200	2,435,000	300,000	240,000	145,000	34,744,200
Non-Snake River Total	30,289,200	104,874,250	34,404,650	6,656,000	300,000	390,000	286,975	177,201,075
Basin Total	39,276,716	105,674,250	34,404,650	17,107,000	300,000	390,000	286,975	197,439,591

Notes:
1. Only the total production in the Snake River (20.2 million) and the total production in the Columbia River Basin (197 million) are specified in the production ceiling included in the proposed recovery plan (usually called the cap). The specie and geographic area of production estimates are made using current production levels.
2. Subsequent yearly hatchery releases change. For example, the 1998 hatchery releases are about 170 million total smolts. These releases are within the framework of the "cap."

Source: U.S. Department of Commerce (March 1995). (This table is not in the report, but was constructed from report data.)

As the cost considerations of hatchery production are included with environmental factors, the overall emphasis is shifting toward natural production, or hatchery operations that strive to supplement natural production. Supplementation strategies are based on increases in habitat productivity. Without increases in habitat productivity, the required supplementation budgets may double over the next 25 years (Smith 1999).

3. Changing Patterns in Salmon Harvests

The history of salmon harvests has been one of transition, from spears and dip nets, to improved and new technologies, such as diesel engines, entrapment nets, and trolling poles. The first canning operations in the western U.S. developed close to population centers in California. As the stocks of the Sacramento River were fished down, the Columbia River fish became more attractive. Most of these fish were harvested by nets (gillnets or seines) or fish wheels. As fish became scarcer and gas powered engines allowed fishermen to venture out farther into the ocean, trolling for salmon became an attractive alternative. As fishermen ventured farther into the ocean, salmon returning to their spawning areas were intercepted. As a result, the river of production (spawning and rearing) is many times no longer the area of harvest. In most parts of Alaska, most salmon are harvested in or close to the river of production. Careful management assures that a sustainable level of spawners escape to each watershed. In the lower part of Alaska, fishing is allowed (including trolling) that targets on salmon produced from and returning to waters in Canada and the U.S. West Coast states. International conflicts arise over these interceptions.

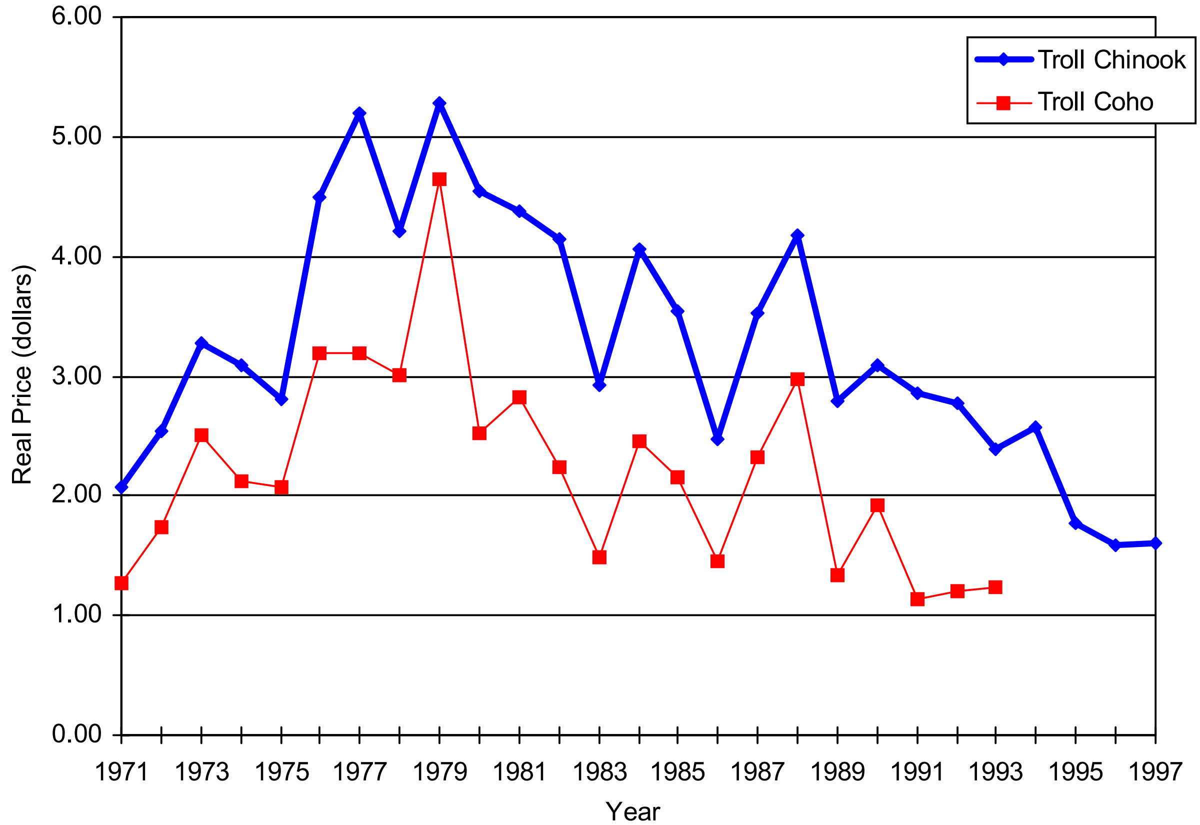
The spawning and production of salmon in a watershed may not be related to the level of harvest in a certain watershed. For example, between the 1870's and 1920's most of the fish produced in the Columbia River system were harvested in Columbia River waters. As ocean fisheries developed, a majority of the fish produced in the Columbia River Basin were harvested in marine waters from California to Alaska. Interestingly, this results in transferring economic investments in Columbia River anadromous fish production to distant economies.

4. Effect of Changing Markets, Production, and Harvests

The squeeze between Alaska's production of canned and frozen salmon and aquaculture's production of fresh salmon puts Columbia River salmon production into a price and market taker position. The real price of troll caught chinook salmon, for example, has decreased from \$5 in the 1980's to less than \$1.50 today (Figure A-2). This is about a 70 percent decline in real prices at a time when most other seafood prices have remained constant. The change from the prized spring chinook to lower quality fall chinook does not allow Columbia River salmon production any competitive or market advantage. The effect of economic development, hatchery production, and mixed stock, open access fisheries has been to reduce the total, and the species composition, of returning salmon to the Columbia River. "Total runs have decreased from about 11 million fish returning per year,[1] before European settlement, to 2.9

1. The NPPC estimated that pre-European development runs were as high as 16 million fish (NPPC, March 1986).

Figure A-2
1971-1997 Annual Commercial Troll Salmon Ex-Vessel Prices Trends
(Adjusted for Inflation, 1997 Base)

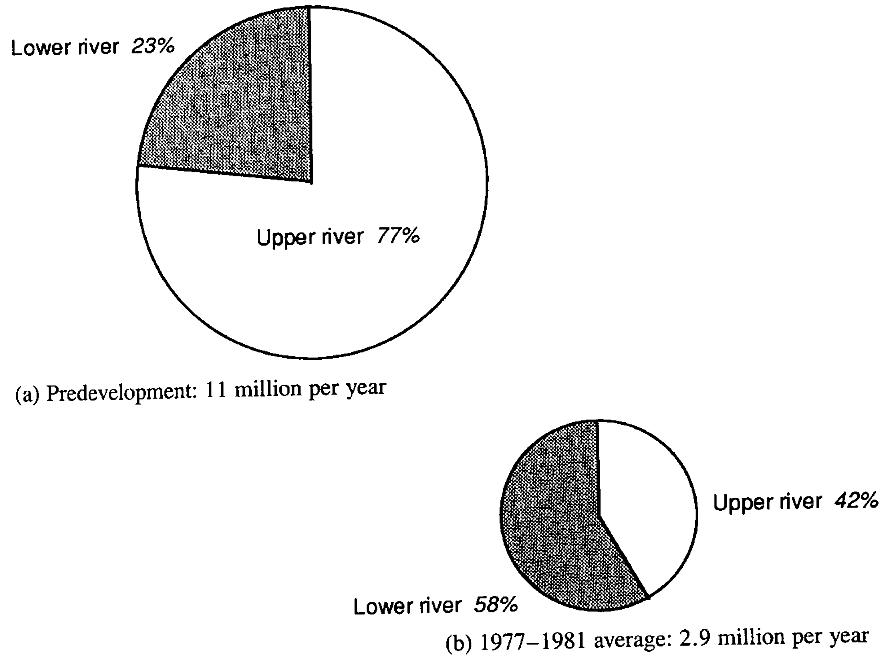


Notes: 1. Prices adjusted to real 1997 dollars using the gross national product implicit price deflator developed by the U.S. Bureau of Economic Analysis.
2. Prices are annual and species averaged and are for Oregon landings only.
3. Average prices for salmon include seasonal and size considerations.
4. Ex-vessel price is the amount paid to fishers at the time of fish delivery.

Source: Radtke and Davis (1999).

million fish (1977-1981 average); sockeye and chum have been mostly replaced; and upper river production of spring and summer chinook has been replaced by lower river returning fall chinook and coho" (Figures A-3a and A-3b) (Lee 1993). Because of unfavorable ocean conditions, such as El Niño events, total adult fish harvested or returning to the Columbia River Basin during the 1990's has been around one to 1.5 million fish.

Figure A-3a
Distribution of Columbia River Salmon, Showing Abundance Above and Below the Site of Bonneville Dam (Area of Circles is Proportional to Estimated Population Sizes)

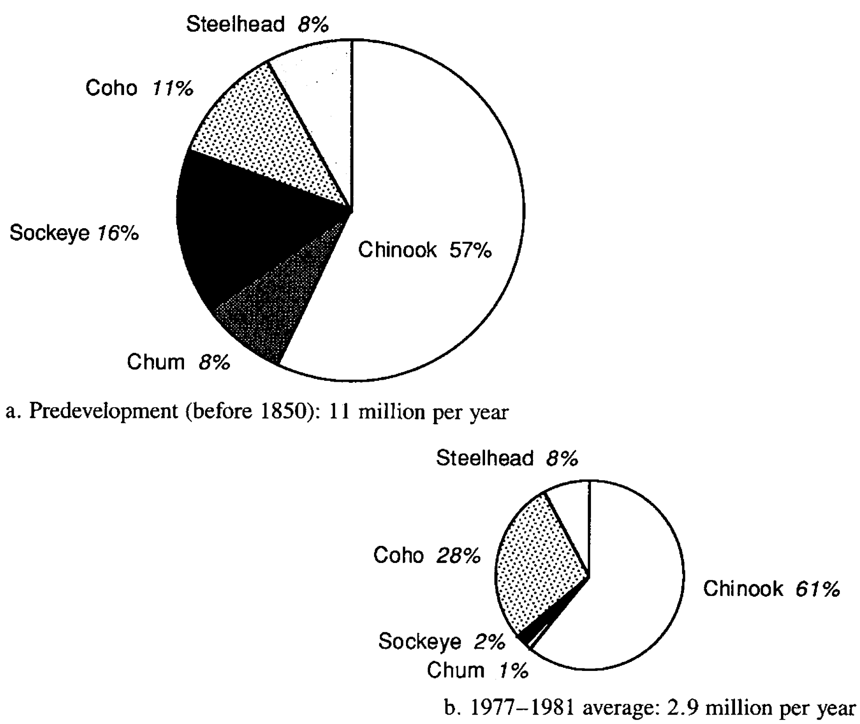


(a) Predevelopment: 11 million per year

(b) 1977–1981 average: 2.9 million per year

Source: Lee (1993).

Figure A-3b
Species Composition of Columbia River Salmon
(Area of Circles is Proportional to Estimated Population Sizes)



a. Predevelopment (before 1850): 11 million per year

b. 1977–1981 average: 2.9 million per year

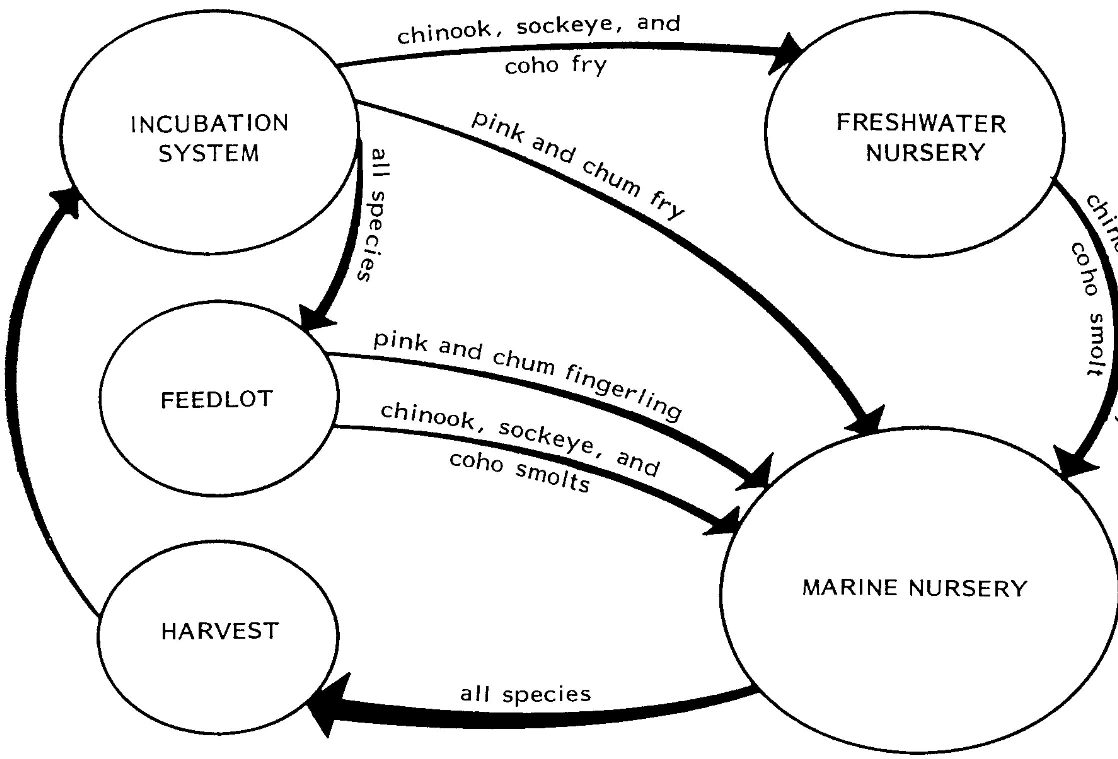
Source: Lee (1993).

CHAPTER II. SALMON MANAGEMENT

A. Background

Salmon are fully migratory and know no jurisdictional or political bounds. They spawn in rivers and estuaries, then migrate as fingerlings into the marine system early in their life cycle, or feed and grow in freshwater for up to a year to migrate into the ocean as smolts weighing as much as 50 grams. Each of the major species of salmon (chinook, coho, sockeye, chum, pinks, and steelhead) have developed their own system of reliance on fresh or marine waters (Figure A-4).

Figure A-4
Processes of Ocean Ranching of Five Species of Pacific Salmon



Source: McNeil and Baily (July 1975).

Artificial propagation seeks to substitute for portions of this cycle. Pink and chums spend very little time in the incubation area and move to the marine nursery soon after the spawned egg moves into the "fish" cycle. Artificial propagation costs tend to be low, about $0.02 per "eyed" egg, and survival rates into fisheries may be very low and still return revenues greater than the cost of propagation. Other fish, such as coho or steelhead that require a longer period of time in fresh water (hatcheries) may cost as much as $0.60 per released smolt. Survival rates to fisheries are therefore an important consideration in artificial propagation management.

Salmon hatcheries were built in the Columbia River system to replace and/or increase natural production. Some of these hatcheries were built as mitigation for specific interruptions (such as dams), others were built for enhancement or economic development objectives. The operation of the mitigation hatcheries may therefore be secondary to the cost considerations of artificial propagation, and the consideration for these mitigation agreements seems to be the number of harvestable adults for any specific area or year.

The migration route of the salmon species and subspecies also varies. Fall chinook from the Columbia River system tend to migrate north through waters off Canada and Alaska, while coho that spawn in the lower Columbia River tend to migrate as far north as do fall chinook (Figure A-5). Steelhead are ocean wanderers that range as far as Russian waters in the Western Pacific.

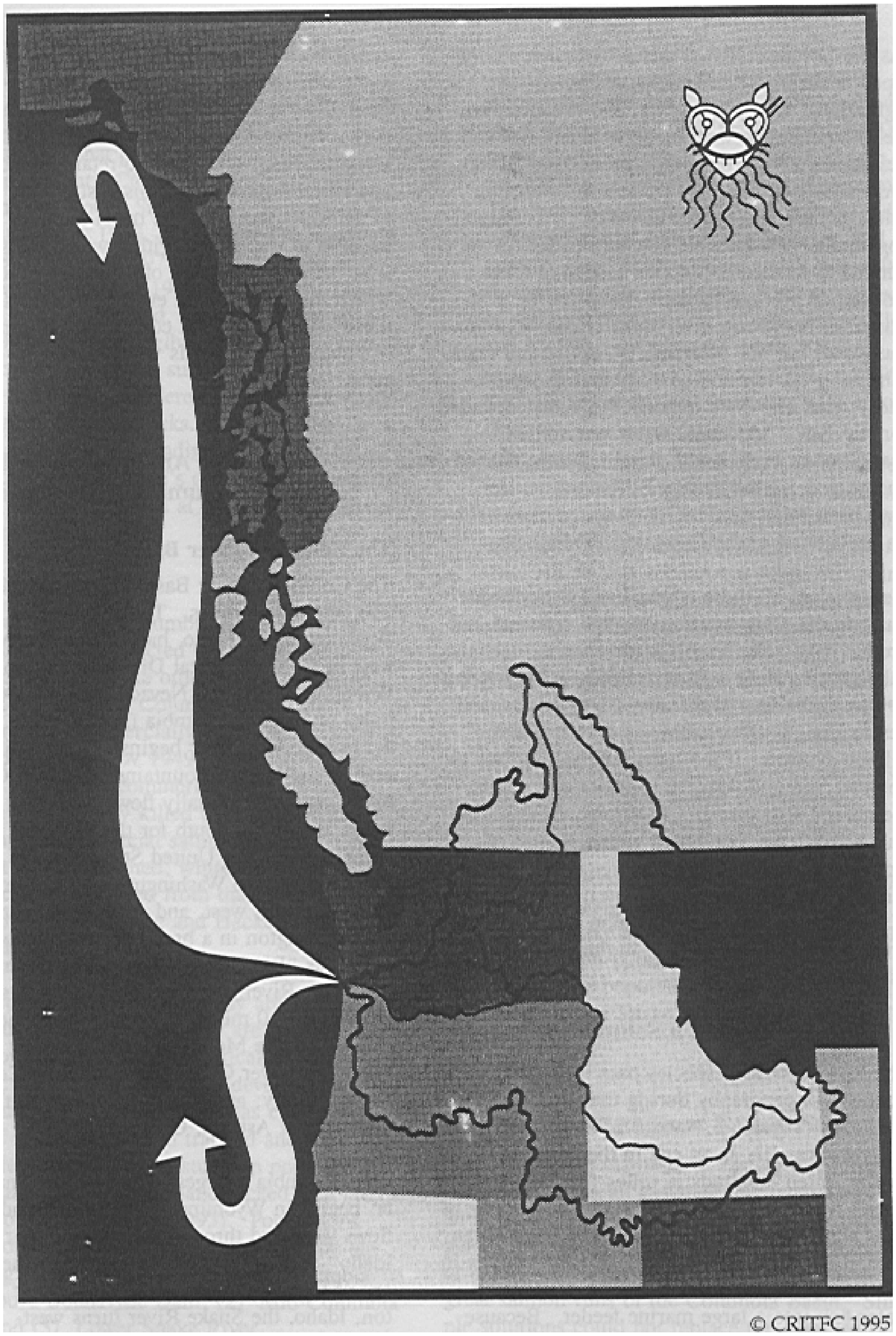
These wide-ranging migratory patterns have made salmon very susceptible to habitat changes and a variety of predators. With technological changes in marine transportation (boats and combustible engines) and fishing gear (monofilament nets and line) man has become the most effective predator in fresh as well as marine waters. The number of salmon that were taken in high seas fisheries after World War II became a concern to many countries. A general understanding has been reached through various international agreements and conventions of a prohibition against directed salmon fisheries in the open oceans or in the high seas (National Research Council 1996, p.262). There has developed an agreement against retention of salmon taken incidentally in fishing for other species. There is also a general agreement that those countries in whose waters salmon originate should receive the primary benefit from these fish.

Salmon harvested in any area are subjected to historical treaties or agreements. Such agreements may or may not be valid for future harvest allocations. The purpose of this chapter is to describe, in general form, some of the major treaties and agreements that affect the harvest of Columbia River Basin produced anadromous fish. Historical harvest patterns and anticipated treaty obligations will be used in estimating future harvest and therefore economic impacts (both regional economic impacts and estimated value impacts) of these harvests.

B. Treaties and Agreements

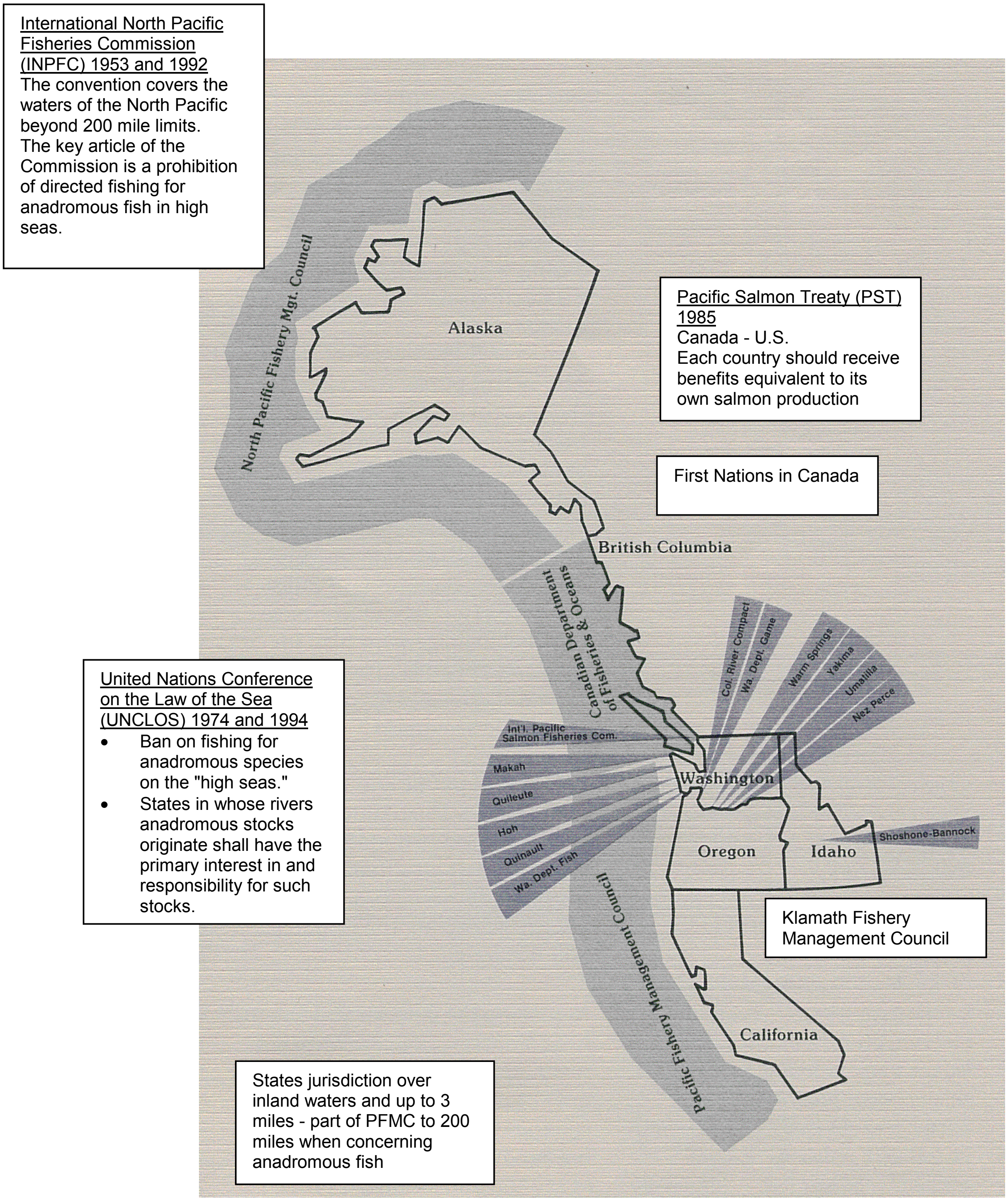
There are a host of salmon treaties and agreements that affect salmon of the Columbia River system. These can be categorized as *international understandings*, such as the 1992 International North Pacific Fisheries Commission (INPFC) Convention (Shepard and Argue, February 1998), the United Nations Convention on the Law of the Sea (UNCLOS) which entered into force in November 1994, the PST between the United States and Canada, *harvest management agreement processes* such as the PFMC, *agreements to rebuild the stocks* such as the Northwest Power Act, *court decisions* that have defined the obligations to Northwest Indian Tribes, and most recently *federal mandates to protect salmon* stocks under the ESA. Figure B-6 depicts some historical regulatory jurisdictions with partial authority over various stocks of salmon and steelhead production in the Columbia River.

Figure A-5
Habitat and Range of Columbia River Basin Anadromous Fish



Source: WY-KAN-USH-MI WA-KISH-WIT (1995).

Figure A-6
Regulatory Jurisdictions With Partial Authority Over Various Stocks of Salmon and Steelhead Produced in the Columbia River and Washington Conservation Areas



Source: NMFS (1984).

The following is a short discussion of some of the agreements, treaties, acts or mandates that affect or may affect the fish that are managed for harvest in any geographic region.

1. The Northwest Power Act of 1980[1]

The waters of the Columbia River system were the basis of a massive program to develop the Northwest. The Columbia River was "tamed" to provide subsidized electricity, irrigation, and navigation for industries and citizens of the west. Some of the costs of this development program began to be realized in the 1960's and 1970's. Demand for cheap power was forecast, and sections of the Pacific Northwest society believed that their historical share in salmon harvests was not being realized. The solution to these emerging issues was the Northwest Power Act of 1980.

"The Act was designed to solve a set of social problems by technological means..... As demand for power grew during the 1970's, more power plants seemed necessary to utilities..... Indian tribes and fishermen...were demanding that the damage to the Columbia's fish runs be repaired.... Congress sought to accommodate them all..... The claims of Indian tribes posed another threat to the region's power supply and economy. After their initial victories over fish harvest, the tribes filed more cases. Rulings in the lower courts suggested that the tribes might be awarded a right to enjoy a productive natural system." (Lee 1993, pp.31-32).

The Northwest Power Act had two principles to prove: that energy conservation made good business sense, and that the Columbia's salmon runs could be salvaged while preserving the dams and their economic benefits. Electric power consumers are obliged to find, through the Bonneville Power Administration, a program to "protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydro-electric project of the Columbia River and its tributaries." (Lee 1993, p.40).

In 1986 the council.....set the responsibility of present-day rate payers at between 8 and 11 million adult fish per year. The loss of this many fish, above and beyond the remaining 2.5 million returning to the river, could be ascribed to hydroelectric power generation...... The biological capability of the remaining habitat and technically feasible hatchery sites may fall well below 8 million fish." (Lee 1993, p.40). "The Columbia River Basin Fish and Wildlife Program has ". . . interim goal of doubling salmon populations over an unspecified time . . . Doubling populations while continuing to harvest at levels similar to those of recent years increases costs and biological risks; large scale reliance on hatcheries is unavoidable . . ." (Lee 1993, p.41).

"[The] requirement to share the catch equally between Indian and non-Indian harvesters forced the creation of a new set of institutional mechanisms to regulate fisheries. The Columbia River Basin program aimed at rebuilding *harvestable* populations of salmon - a goal that requires hatcheries. The Council continued, however, to defer to the authority of the fisheries management agencies and Indian tribes on matters concerning harvests. Supplementation thus promises effective use of existing and new hatchery capacity together with the hope of

1. Much of this section is from Lee (1993).

rebuilding wild stocks in their native streams and at population levels that will permit harvest." (Lee 1993, p.42).

The above discussion is included as a background to the NPPC's goal to "double the salmon runs." For a more detailed discussion on the legal aspects of the Columbia River Basin Fish and Wildlife Program, refer to WY-KAN-USH-MI WA-KISH-WIT (1995).

2. Pacific Salmon Treaty 1985

Because salmon have been intercepted in the high seas with gear such as large drift nets, a general agreement has been reached on the "area of origin concept" as it applies to anadromous fish stocks. The principle is that the benefits of enhancement should accrue principally to the nation that makes the enhancement investment. Incentives are therefore created for each country to conserve and enhance valuable salmon stocks by establishing fishery regimes which will substantially reduce the interception of each nation's stocks by the other nation.[1]

The concept is simple, but bogs down in detail of what constitutes a nation's waters. Does this include the three mile state waters or the 200 mile EEZ, or does the definition include only fresh water and river estuaries?

Provisions of the 1985 PST between the United States and Canada require that "each Party shall manage its fisheries and its salmon enhancement programs so as to...provide for each Party to receive benefits equivalent to the production of salmon originating in its waters." (Article III, paragraph 1b) Recognizing that it is not possible to fully eliminate interceptions of salmon by the two countries without unacceptably disrupting traditional fisheries of both countries, the Treaty nevertheless seeks to ensure that each country receives benefits *equivalent* to its own salmon production. The Treaty does not specify exactly how the "equity principle" is to be implemented, but rather leaves this task to the Pacific Salmon Commission (PSC), implementing body of the Treaty.[2] By fishing off each other's salmon stocks for some agreed upon quota, both countries have overfished the stocks. Alaska is advocating an "abundance based" fishery that takes into account the time that salmon "graze" in their waters. Canada maintains that a large share belongs to them based on the originating principle.

As of April 1998 negotiations are underway between Canada and the United States on the sharing of salmon that may intermingle in each other's waters. A recent historic sharing of salmon produced from the Columbia River system may provide an indication of Canadian salmon harvests of Columbia River system produced salmon.

For every ten coho and chinook salmon produced in Washington, Oregon and Idaho, six or more are harvested in Canada. Conversely, U.S. citizens of the Pacific Northwest harvest runs

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1. Comments made during the negotiation of the United Nations Law of the Sea Convention. Taken from Shepard and Argue (1988).
2. Taken from a paper prepared by U.S. participants for the Pacific Salmon Commission Workshop on Valuation Methodologies, held on September 23-25, 1991 at Kah-Nee-Ta, Oregon.

of sockeye and pink salmon which originate in Canada. Alaska fisheries also intercept chinook salmon from the lower Pacific Northwest and Fraser River (Canada) sockeye.

The central theme of the PST is that harvests and interceptions of each other's salmon may be controlled, and that naturally spawning salmon could be protected while at the same time increasing the abundance of hatchery produced salmon. Two major problems have emerged that may affect the success of the PST. One is the issue of equity and what constitutes "producing waters." Alaska, as part of the U.S. delegation, argues that fish that migrate through its waters are "grazing" on its resources, and that the time the salmon spend in Alaskan waters should be counted as salmon "originating" in these waters. The second issue is the reliance on hatchery production. As ocean conditions have changed due to factors such as El Niño, salmon ocean survival has decreased to record historic lows. Expectations of increased harvests driven by increased hatchery capacity have not materialized, resulting in the carefully negotiated allocation agreements not being met.

The PSC determines the allowable total salmon to be harvested by the U.S. and Canada. Major provisions of the PST that affect Columbia River stocks.

- Southeast Alaska - Treaty quota of 263,000 chinook for the troll fishery
- Northern British Columbia - Treaty quota of 263,000 chinook for the troll fishery
- West Coast Vancouver Island - Treaty quota of 360,000 chinook and 1.8 million coho
- Georgia Strait Sport and Troll - Treaty quota of 275,000 chinook

The PSC's primary function is to control harvest. Concurrent with catch restraints in PSC fisheries, the management agencies are required to "pass through" any fish saved by the curtailed PSC fisheries so that these fish would principally accrue to the spawning grounds. This "pass through" agreement requires certain restraints on the U.S. domestic fisheries not to intercept fish needed to rebuild the spawning population of depressed salmon runs in local rivers.

3. Pacific Fishery Management Council

The PFMC is the primary agency that manages the harvests of salmon in the waters off Washington, Oregon and California. The PFMC provides guidance to the U.S. Secretary of Commerce on the management of fisheries in waters off Washington, Oregon, and California. All fisheries of the Columbia River are established within the guidelines and constraints of the CRFMP, the ESA, and management agreements negotiated between the parties to U.S. v. Oregon.

The PFMC was established as one of eight regional councils in the U.S. that would regulate the fisheries in waters off the shores of the U.S. according to principles and objectives of the Magnuson Act of 1976. Fisheries are managed according to established Fisheries Management Plans (FMPs) that may be amended. A general description of the existing and proposed renewed salmon management plans as they relate to the Columbia River produced salmon follows.

a. Management Unit

Pacific Coast salmon are managed by the PFMC in accordance with Section 11.0 of the Pacific Coast Salmon Plan as revised in 1996.[1] The management unit includes those stocks of salmon of U.S. origin that are harvested in the exclusive economic zone (EEZ) off the coasts of Washington, Oregon, and California. Exceptions are those stocks which are managed there by another management entity with primary jurisdiction, (i.e. sockeye and pink salmon by the Fraser River Panel of the PSC in the Fraser River Panel Area (U.S.) between 49°N and 48°N latitude. Chinook and coho salmon are the main species caught in the ocean salmon fisheries operating off Washington, Oregon, and California. The catch of pink salmon in odd-numbered years is also significant. The management unit represents a coast wide aggregate of salmon stocks which are further broken down by species into principal stock components for ocean management purposes. The principal stock components represent a stratification by shared life-history traits, habit preference, and genetic similarities to facilitate greater management sensitivity to trends in regional abundance and increase the protection of the genetic diversity found within the coverage area. Table A-3 contains a complete listing of the principal stock components in the Salmon FMP.

Active management consideration is given to each principal stock component which is either significantly impacted by PFMC fisheries or listed under the ESA. The principal stock components which meet the exploitation rate criteria, represent populations where ocean impacts can directly effect the achievement of their management objectives. For listed principal stock components, the PFMC's annual harvest management plans are developed to be consistent with guidance provided by the NMFS regarding recovery plan objectives or proposed jeopardy standards. Principal stock components monitored as the result of ESA action, denote populations where harvest impacts may be of increased significance and need to be considered during the course of developing annual harvest management plans.

Although the FMP's management approach is focused on greater protection of natural stocks, hatchery stocks are also important contributors to the ocean fisheries. Within some principal stock components, hatchery stocks are an important management consideration and may be included as key stock or stock groups. Where hatchery stocks are designated as key stock or stock groups, management considerations for these stocks will be taken into account, but application of overfishing requirements do not extend to the hatchery stocks. A general description of the basic management considerations for each principal stock component from the Columbia River is provided below.

Table A-3
Principal Stock Components in the PFMC Salmon FMP

CHINOOK	COHO

1. Much of the material on the PFMC is from *Review of Ocean Salmon Fisheries* for Various Years, PFMC, Portland, Oregon.

Sacramento River Winter-Run Central Valley Spring-Run Central Valley Fall/Late Fall-Run Klamath River Southern Oregon/California Coast Oregon Coast Snake River Fall-Run Snake River Spring/Summer-Run Upper Columbia River Summer/Fall-Run Upper Columbia River Spring-Run Mid-Columbia River Spring-Run Lower Columbia River Upper Willamette River Washington Coast Puget Sound	Central California Coast Southern Oregon/Northern California Coast North/Central Oregon Coast Columbia River Southwest Washington Olympic Peninsula Puget Sound **PINK** Puget Sound

i. Columbia River - Coho

Coho salmon stocks originating from within the Columbia River represent this principal stock component. The freshwater fauna of this principal stock component is distinctive for its extensive estuarine habitat. Ocean distribution for these populations includes Oregon, Washington, and British Columbia coastal waters.

ii. Snake River Fall Run - Chinook

Populations of fall chinook returning to the Snake and Deschutes Rivers are included in this principal stock component. These populations exhibit ocean-type life history traits, with a more southerly migration pattern than the upper Columbia River populations. Tag recoveries occur from ocean fisheries spanning from California to Alaska. Ecologically, this region represents a high desert plain with annual rainfall varying between 25 to 50 cm.

iii. Snake River Spring/Summer Run - Chinook

Included in this principal stock component are stream-type chinook salmon populations from the upper reaches of the Snake River Basin. These populations emigrate to the ocean as yearlings, mature at ages four and five, and are rarely taken in ocean fisheries. Spawning occurs at elevations of above 1,000 meters in streams where winter snowpack is the major contributor to stream flows. Peak flows occur with spring melt in May or June lasting only two to three months.

iv. Upper Columbia River Summer/Fall Run - Chinook

All ocean-type chinook populations spawning in areas between McNary Dam and Chief Joseph Dam comprise this principal stock component. These populations generally mature at an older age than ocean-type chinook from the lower Columbia and Snake Rivers. This component exhibits a stronger northerly distribution pattern than the Snake River populations, contributing predominantly to ocean fisheries in British Columbia and Alaska.

v. Upper Columbia River Spring Run - Chinook

This principal stock component comprises stream-type chinook salmon populations spawning above Rock Island Dam, primarily in the river systems of the Wenatchee, Entiat and Methow. These populations exhibit classical stream-type life history strategies: yearling smolt emigration with only rare tag recoveries in coastal fisheries. Ecologically, these populations originate from drainages of the eastern Cascades, relying on snow melt for peak spring flows. These waters tend to be cooler and less turbid than the Snake and Yakima Rivers to the south. Spawning occurs at elevations between 500 and 1000 meters.

vi. Mid-Columbia River Spring Run - Chinook

Included in this principal stock component are stream-type chinook salmon spawning in the Klickitat, Deschutes, John Day, and Yakima Rivers. Stream-type life history traits are characterized by smolt emigration as yearlings. The majority of adults in this component spawn as 4-year-olds, with the exception that return to the upper tributaries of the Yakima River which return as 5-year-olds. These populations are genetically distinct from other stream-type populations in the basin. Streams in this region drain desert areas east of the Cascade range and are ecologically differentiated from the colder, less productive, glacial streams of the upper Columbia and from the generally higher elevation streams of the Snake River.

vii. Lower Columbia River - Chinook

All chinook salmon populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls, are within this principal stock component. All of these stocks are considered ocean-type. These populations tend to mature at ages three and four, somewhat younger than the surrounding regions. Their ocean distribution is northerly, but with little contribution to the Alaska fishery.

viii. Upper Willamette River - Chinook

This principal stock component includes the spring chinook populations above the Willamette Falls. These populations have an unusual life history of sharing both the stream and ocean-type life history traits. This component attains maturity in its fourth and fifth year of life, with slightly more four-year-old fish. Ocean distribution is consistent with an ocean-type life history, considerable tag recoveries occur in the coastal fisheries of British Columbia and Alaska. Ecologically, the Willamette Valley experiences a rainshadow effect from Cascade Range which limits rainfall and produces peak flows in December and January. The Willamette Falls offered a narrow temporal window for upriver migration, which may have promoted isolation for the other Columbia River stocks.

b. Management Considerations

Outlined below is a general discussion of the management considerations associated with each primary ocean management area. Within these areas there is a presence of several different principal stock components requiring an integration of varying harvest objectives. For some of the principal stock components, achievement of the specific harvest objectives associated with ocean fisheries is also conditioned upon fulfilling federal trust obligations to Indian tribes with federally reserved fishing rights and inside non-Indian net and recreational fisheries needs. Each year specific regulatory measures are implemented that are intended to achieve a balance between the harvest objectives for the various ocean and inside fisheries. The following discussion identifies those components and ocean areas where harvest objectives related to treaty obligations and inside fishery needs are of significance.

i. South of Cape Falcon, Oregon Management Unit for Coho

Columbia River, Oregon and California coho are managed together within the framework of the Oregon Production Index (OPI) since these fish are essentially intermixed in the ocean fishery. These coho contribute to ocean fisheries off the southern Washington coast as well as to fisheries off the coasts of Oregon and northern California. Ocean fishery objectives for the OPI area address the following: (1) conservation and recovery of Oregon and California coastal coho; (2) the desire for viable fisheries inside the Columbia River; and (3) impacts on management objectives for other key stock or stock groups.

The OPI is used as a measure of the annual abundance of adult three-year-old coho salmon resulting from production in the Columbia River and in Oregon and California coastal basins. The index itself is simply the combined number of adult coho that can be accounted for within the general area from Leadbetter Point, Washington to as far south as coho are found. Currently, it is the sum of (1) ocean sport and troll fishery impacts in the ocean south of Leadbetter Point, Washington, regardless of origin; (2) Oregon and California coastal hatchery returns; (3) the Columbia River in-river runs; (4) Oregon coastal natural spawner escapement and (5) Oregon coastal inside fishery impacts. Most of the California production is from hatcheries which provide a very small portion of the total hatchery production in the OPI area.

ii. North of Cape Falcon, Oregon Management Unit for Coho

Management of ocean fisheries for coho north of Cape Falcon is complicated by an overlap of OCN stocks in the vicinity of the Columbia River mouth. Allowable harvests in the area between Leadbetter Point, Washington and Cape Falcon, Oregon will be determined by an annual blend of OCN and Washington coho management considerations including:

- Abundance of contributing stocks.
- Stock specific management objectives.
- Consultation standards of the ESA.
- Relative abundance of chinook and coho.
- Allocation considerations of concern to the PFMC.

Coho occurring north of Cape Falcon, Oregon are comprised of a composite of coho stocks originating in Oregon, Washington, and southern British Columbia. Ocean fisheries operating in this area must balance management considerations for stock specific management objectives for Southern Oregon/Northern California, Oregon Coast, Southwest Washington, Olympic Peninsula, and Puget Sound.

iii. South of Horse Mountain Management Unit for Chinook

Within this area, considerable overlap of chinook originating in Central Valley and northern California coastal rivers occurs between Point Arena and Horse Mountain. Ocean commercial and recreational fisheries are managed to address impacts on chinook stocks originating from the Central valley, California Coast, Klamath River, Oregon Coast, and the Columbia River. With respect to California stocks, ocean commercial and recreational fisheries operating in this area are managed to maximize natural production consistent with meeting the U.S. obligation to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas.

iv. Horse Mountain to Humbug Mountain Management Unit for Chinook

Major chinook stocks contributing to this area originate in streams located along the Southern Oregon/California coasts as well as the Central Valley. The primary chinook run in this area is from the Klamath River system, including its major tributary, the Trinity River. Ocean commercial and recreational fisheries operating in this area are managed to maximize natural production of Klamath River fall and spring chinook consistent with meeting the U.S. obligations to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas. Ocean fisheries operating in this area must balance management considerations for stock-specific management objectives for Klamath River, Central Valley, California Coast, Oregon Coast, and Columbia River chinook stocks.

v. Humbug Mountain to Cape Falcon Management Unit for Chinook

The major chinook stocks contributing to this area primarily originate in Oregon coastal rivers located north of Humbug Mountain, as well as from the Rogue, Klamath and Central Valley systems. Allowable ocean harvests in this area are an annual blend of management considerations for impacts on chinook stocks originating from the Central Valley, California Coast, Klamath River, Oregon Coast, Columbia River, and the Washington Coast.

vi. Cape Falcon to United States/Canada Border Management Unit for Chinook

The majority of the ocean chinook harvest in this area primarily originates from the Columbia River, with additional contributions from Oregon and Washington coastal areas. Bonneville Pool (tules) falls and lower Columbia River (tules) falls and springs (Cowlitz), all primarily of hatchery origin, comprise a majority of the ocean harvest between Cape Falcon, Oregon, and the U.S. - Canada border. Hatchery production escapement goals of these stocks are established according to long-range production programs and/or mitigation requirements associated with displaced natural stocks. Allowable ocean harvest in this area is a blend of management considerations for impacts on chinook stocks originating form the Oregon Coast, Columbia River, Washington Coast, and Puget Sound.

vii. Pink Salmon Management Unit

Ocean pink salmon harvests occur off the Washington coast and are predominantly of Fraser River origin. Pink salmon of Puget Sound origin represent a minor portion of the ocean harvest although ocean impacts can be significant in relation to the terminal return during years of very low abundance. The Fraser River Panel of the PSC manages fisheries for pink salmon in the Fraser River Panel Area (U.S.) north of 48° N latitude to meet Fraser River natural spawning escapement and U.S. - Canada allocation requirements. The PFMC manages pink salmon harvests in that portion of the EEZ which is not in the Fraser River Panel Area (U.S.) waters consistent with Fraser River Panel management intent. Pink salmon management objectives must address meeting natural spawning escapement objectives, allowing ocean pink harvest within fixed constraints of coho and chinook harvest caps and providing for treaty allocation requirements.

c. Recent Years Harvests of Major Columbia River Stocks

i. Lower Columbia River Spring Chinook

The 1997 minimum in-river run size of lower river adult spring chinook is estimated at 45,500 fish, improved over the 1996 return of 39,200 fish, but below the 1986-1990 average return of 131,500 fish. For 1997, the winter season commercial salmon fishery was closed because of the very poor runs of spring chinook that were projected to return to lower river areas. The early season mainstem lower river recreational fishery was closed on March 11 to provide maximum protection for depressed lower river spring chinook stocks.

ii. Upper Columbia River Spring and Summer Chinook

The 1997 in-river run size of adult spring chinook destined for areas above Bonneville Dam was 114,100 fish, over twice the 1996 return of 51,500, and over ten times the record low of 10,200 fish in 1995. Lower river fishery impacts on adult upriver spring chinook in 1997 were limited to incidental mortality in commercial fisheries, and ceremonial and subsistence fisheries. The in-river harvest impact rate on adult wild Snake River spring chinook was estimated at 7.3 percent in 1997, compared to 5.5 percent in 1996 and the 1986-1990 average impact rate of 10.7 percent.

Major fisheries targeting summer chinook in the Columbia River have been eliminated since 1964 due to chronically depressed status of this stock. In 1997, escapement of upriver spring chinook was 105,800, over twice the 1996 escapement of 48,700 and 92 percent of the interim goal of 115,000 adults. Escapement of upper Columbia River summer chinook was 27,600 adults, 78 percent above the 1996 escapement of 15,500 adults, but still far below the goal of 80,000 - 90,000 adults. The 1997 escapement of adult wild Snake River spring chinook at

Lower Granite Dam was estimated at 1,400 fish, well below the 1986-1990 average return of 5,900 fish and the interim management goal of 25,000 adults.

iii. Columbia River Fall Chinook

Historically, four stocks have contributed significantly to the Columbia River fall chinook fisheries. These include two lower river stocks, lower Columbia River Hatchery (LRH) tules and Columbia River Wild (LRW) chinook, and two upper river stocks, Spring Creek Hatchery (SCH) tules and upriver bright (URB) chinook.

Total ocean escapement of all Columbia River fall chinook stocks was similar to the expected 1997 returns, with greater than expected returns of LRW stocks, but less than expected returns of the mid-Columbia River bright stocks. Ocean fisheries impacting the Columbia River Chinook stocks in 1997 were restricted by U.S. and Canada managers in order to provide needed conservation measures to protect and rebuild depressed chinook stocks. PFMC area and treaty Indian ocean chinook fisheries north of Cape Falcon were restricted in 1997.

4. Columbia River Compact

The challenges of salmon harvest management in the 1960's and 1970's resulted in jurisdictional guidelines for future Columbia River produced salmon harvests. The decision in the *U.S. versus Washington and Oregon* provides for an equal sharing of harvestable salmon between treaty and non-treaty entities (ODFW, October 1998). The judicial decision defines equal harvest sharing as 50/50 (50 percent treaty and 50 percent non-treaty) of the upriver destined chinook available for harvest in the ocean south of the Canadian border and in the mainstream of the Columbia River below Priest Rapids Dam. The management entity is the Columbia River Compact and the CRFMP (ODFW/WDFW, January 1998). The Columbia River Compact is the entity charged with congressional and statutory authority to adopt seasons and rules for Columbia River commercial fisheries. Member agencies are:

Oregon Department of Fish and Wildlife (ODFW)
Washington Department of Fish and Wildlife (WDFW)
Washington Fish and Wildlife Commission (WFWC)

In addition, the Columbia River treaty tribes have authority to regulate treaty Indian fisheries. When addressing commercial seasons for salmon, steelhead and sturgeon, the Compact must consider the effect of the commercial fishery on escapement treaty rights and sport fisheries, as well as the impact on species listed under the ESA.

"The harvest allocation provisions of this agreement apply only to the ocean fisheries south of the Washington/British Columbia border and the mainstem fisheries as herein defined unless otherwise expressly indicated." (ODFW 1998, p.5). The following are in-river management guidelines of the CRFMP.

a. Spring/Summer Chinook

Harvest of upriver spring chinook occurs primarily after mature fish return to freshwater. The ocean harvest rates are less than anticipated (two percent) when the plan was drafted. The current assessment is that upriver spring chinook are not known to be harvested significantly in ocean fisheries, probably due to timing and structure of fishing seasons.

The CRFMP provides that on runs between 50,000 and 112 percent of the Bonneville Dam management goal of 115,000, the mainstream harvest below Bonneville Dam is limited to 4.1 percent and in no event should exceed 5.0 percent of the upriver run. Treaty platform, gillnet, and ceremonial and subsistence (C&S) fisheries in Zone 6 are limited to seven percent of the run.

Based on Coded Wire Tag (CWT) recoveries (McCall Hatchery), the ocean distribution of Snake River summer chinook may be similar to that of spring chinook, and therefore not significantly harvested in the ocean.

The allowable non-Indian spring chinook harvest rates are described by a matrix (Table A-4a) that is based on the Willamette return and either the aggregate upriver or Snake River wild return.[1] Based on the projected 1997 returns, a harvest rate of two percent was allowed on upriver spring chinook for non-Indian fisheries under the Management Agreement. The Management Agreement provides that non-Indian commercial and recreational impacts on summer chinook and sockeye (runs) will be minimized to the degree possible, but shall not exceed one percent of the run.

The treaty Indian spring chinook harvest matrix is based on the aggregate upriver return and the Snake River wild return (Tables A-4a through A-4c). The Management Agreement states that treaty Indian summer chinook catch shall not exceed five percent of the run and the treaty Indian catch of sockeye is linked to the run size.

Table A-4a
Non-Indian Fisheries Spring Chinook Harvest Rate Matrix

Select the More Conservative of:		Willamette Spring Chinook Run Size (thousands)			
Aggregate Upriver Spring Chinook Return (thousands)	Snake River Wild Spring Chinook Return (thousands)	<50	50-75	75-100	>100
<50	<5	1%	1%	1%	--
50-115	5-7.5	2%	2%	<2.5%	--
50-115	7.5-10	2%	2%	3%	--
>115	>10	2%	2%	<3%	--
<115	>10	--	--	--	--

Note: "--" denotes further discussion by the Parties.
Source: ODFW/WDFW (January 1998).

1. Much of the following material on spring chinook is taken from the ODFW/WDFW Joint Staff Report (January 1988).

Table A-4b
Treaty Indian Fisheries Spring Chinook Harvest Rate Matrix

Select the More Conservative of:		
Aggregate Upriver Spring Chinook Return (thousands)	Snake River Wild Spring Chinook Return (thousands)	Appropriate Harvest Rate
<50	<5	5%
50-115	5-10	7%
<115	>10	CRFMP (5% or 7%)
>115	NA	--

Note: "--" denotes further discussion by the Parties.
Source: ODFW/WDFW (January 1998).

Table A-4c
Treaty Indian Fisheries Sockeye Harvest Rate Matrix

Aggregate Upriver Sockeye Run Size	Appropriate Harvest Rate
>50,000	5%
50,000-75,000	7%
>75,000	--

Note: "--" denotes further discussion by the Parties.
Source: ODFW/WDFW (January 1998).

b. Fall Chinook

The upriver fall chinook run is managed under the terms of the CRFMP to consist of two stocks: the Bonneville Pool Hatchery (BPH) and Upriver Bright Stock (URB) both hatchery and wild.

Ocean and in-river fisheries have experienced major changes as a result of U.S. v. Oregon litigation, enactment of the Magnuson Act, the U.S./Canada PST, and Endangered Species consideration. The general harvest management guideline, over and above minimum escapement needs, is that 50 percent of the adult chinook produced by mitigation funds should enter the Columbia River annually.

“Treaty Indian and non-Indian fisheries shall share equally (50 percent each) the upriver fall chinook available for harvest in the Pacific Ocean south of the southwesterly projection of the United States-Canada boundary between British Columbia and Washington, and in the mainstem Columbia River below Priest Rapids Dam. Treaty Indian and non-Indian fisheries in Columbia River tributaries, other than the mainstem Columbia River between McNary and Priest Rapids dams, shall be excluded from this allocation and shall be covered by the subbasin plans (ODFW 1998, p.29).

c. Steelhead

Upriver summer steelhead were once abundant in the Columbia River Basin and were harvested commercially along with other anadromous stocks. Between 1892 and 1896, combined runs of summer and winter steelhead were estimated to range as high as 554,000 adults. Average annual catch of summer steelhead during this period was estimated at 382,000 fish (TAC 1997). Habitat degradation and overfishing caused substantial declines of runs during the late 1800's and early 1900's and continued into the mid 1900's. Commercial landing of steelhead by non-Indians was prohibited beginning in 1975 (ODFW/WDFW 1998).

Steelhead are presently managed under the Columbia River Fish Management Plan (CRFMP) (TAC 1997).

Summer steelhead make up the bulk of the present steelhead runs. Summer steelhead are divided into two groups, A and B, under the terms of the CRFMP. Group A steelhead originate in production areas throughout the Columbia Basin. Group B adult steelhead originate only in the Clearwater and Salmon River drainages in Idaho. The CRFMP limits treaty Indian fall fisheries to 15 percent of the wild A and 32 percent of the wild B run on wild runs less than 75,500 fish, as measured at Bonneville Dam.

The CRFMP contains no management or escapement goals for hatchery steelhead. According to the CRFMP, the relative abundance of Group A and Group B steelhead is to be considered in setting seasons, so tributary fishing opportunities of the parties to the CRFMP are not precluded and treaty Indian and non-Indian fisheries can harvest a fair share of salmon and steelhead runs. Neither the treaty Indian nor non-Indian catches are to exceed 50 percent of the aggregate of harvestable steelhead (hatchery plus natural/wild) in the mainstem and tributaries (TAC 1997, Tab 8, p.5).

5. Endangered Species Act and Allowable Harvest Considerations

The purpose of the ESA is to provide a means whereby the ecosystems upon which endangered species and threatened species depend, may be conserved to provide a program for the conservation of such species, and to take steps as may appropriate to achieve the purposes of various international treaties and conventions.[1] The ESA is a process for listing, protection and recovery of certain species, subspecies, and distinct populations.[2]

Alaska and West Coast salmon fisheries impact the following Columbia River anadromous fish species that are currently (September 1999) listed under the ESA:

Chinook
Snake River spring/summer (threatened);
Snake River fall (threatened);
Lower Columbia River (threatened);
Upper Willamette River (threatened);
Upper Columbia River (threatened);

Coho
Lower Columbia River/Southwest Washington (candidate);

Chum
Columbia River (threatened);

1. Most of this section is from WY-KAN-USH-MI WA-KISH-WIT, p. 4-10.
2. Much of the following is from Review of Ocean Salmon Fisheries for Various Years, PFMC, Portland, Oregon.

Sockeye
Snake River (endangered);

Steelhead
Upper Columbia River (endangered);
Lower Columbia River (threatened);
Snake River Basin (threatened);
Upper Willamette River (threatened); and
Middle Columbia River (threatened).

In addition, the recovery of several other Oregon and Washington coast and Puget Sound chinook and coho salmon and steelhead species are listed. Guidance for the management of these stocks will affect future Columbia River anadromous fish fisheries.

Alaska and West Coast managed ocean fisheries have identifiable impacts on only Sacramento River winter chinook, Snake River fall chinook, and the coho stocks. Based on the 1988-1993 average, the total mortality of Snake River fall Chinook due to all ocean salmon fisheries is proportioned as: 26 percent for the West Coast fisheries, 12 percent for southeast Alaska and 62 percent for Canada.

NMFS issues biological opinion for listed stocks that require fisheries management practices to meet objectives to avoid jeopardizing the recovery of the listed stocks. For example, the objectives for the stocks that have identifiable impacts from ocean fisheries are as follows.

- For Sacramento River winter chinook, achieve a 31 percent increase in the age three adult cohort replacement rate relative to the 1989-1993 mean rate.

- For Snake River fall chinook, barring an agreement among the parties to the PST to meet conservation needs of chinook salmon, harvest impacts of ocean fisheries in the West Coast and Alaska fisheries, or of all ocean fisheries, cannot exceed 50 percent or 70 percent, respectively, of the 1988-1993 average exploitation rate on age three and age four fish.

- For Central California, southern Oregon/northern California and OCN coho in 1998, limit impacts on OCN coho from West Coast area fisheries to no more than 13 percent and prohibit retention of coho in all catch areas that significantly impact listed coho. In addition, as a surrogate for southern Oregon/northern California coho, limit impacts on Rogue/Klamath hatchery coho to no more than 13 percent.

- For Columbia River fisheries, there are NMFS BO that specify like management objectives.

The PFMC and the North Pacific Fishery Management Council (NPFMC), through the State of Alaska, develop management plans to achieve the stock recovery plans. Similarly the

Columbia River fisheries are under a court order to have CRFMP consistent with stock recovery plans.

The NMFS 1995 Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 1995) concluded that major changes were needed to significantly increase salmon survival. NMFS called for a detailed evaluation of alternative configurations and operations of the four federal hydroelectric projects on the lower Snake River. The purpose of the evaluation was to determine the likelihood that drawdown (breaching) of these four dams, or some other alternative such as expansion of the juvenile fish transportation program, would result in the survival and recovery of Snake River salmon and steelhead. The Corps initiated the evaluation with the Lower Snake River Juvenile Salmonid Migration Feasibility Study of which this study is one element. The Corps in-turn requested that the NMFS summarize available information on the potential effects of the management options on anadromous salmon and steelhead runs originating within the Snake River system. Because the effect of any hydrosystem action would be embedded in the broader relationship between fish and their environment, management actions were evaluated by NMFS (1999) in the context of factors that might occur outside the direct control of the hydrosystem (such as hatcheries output and changes in habitat, harvest, and ocean conditions). The NMFS (1999) conclusions pertaining to the adequacy of PATH results have been incorporated into this study.

C. Salmon Management Considerations

Because salmon range over a large geographic area both in inland waters and in the ocean, production and harvest management is very complex. As previously discussed, there are four general principles or agreements that give direction to production and harvest management. These four principles are international agreements on salmon interceptions, the PST, PFMC Salmon Management Plan, and the Columbia River harvest agreements. In addition, the ESA restricts the amount of wild salmon that may be harvested directly or indirectly once a species or sub-species has been placed on the threatened or endangered species list. Any forecast of future salmon harvests from Columbia River production has to include some or all of these considerations.

CHAPTER III. SURVIVAL RATES AND CONTRIBUTION TO FISHERIES

A. Historical Hatchery Survival Rates

The states in the Pacific Northwest and the federal government have funded hatchery salmon production for more than 100 years. This activity has been continually viewed as a relatively simple solution to persistent problems of habitat loss and overfishing. From the earliest efforts well into the 1960's, most production relied primarily on release of salmon fry with a gradual shift toward holding fish to fingerling size for stocking. By the 1960's, hatchery programs began holding fish for release as full term smolts.

Hatchery smolt production costs are only one component of the unit cost of a harvested adult. The unit cost of production allows an evaluation of a hatchery to control costs and reflect one part of the efficiency of an operation. However, smolts are not sold or caught, only harvestable adults. Therefore, the number of adults surviving gives a better evaluation of individual hatcheries and of the hatchery program in general. The number of returning wild spawners is also crucial to the survival of the species and to contribution to any harvests. Since only limited information is available on survival and harvest rates of wild fish, this section discusses the information available through the hatchery program. There is speculation that wild fish survive at higher rates. One study suggests that wild fall chinook in the lower Columbia River survive "at an average rate that may be as high as 12 times greater than the average of Columbia River hatchery stocks." (McIsaac 1990).

There is no consistent policy to include the differential survival rates of wild and hatchery fish in production or harvest management of Columbia River produced salmon. "Enhancement" studies in the 1970's generally focused on the engineering of hatchery ponds and assumed fairly high survival rates to justify these projects (Table A-5) (Kramer, Chin & Mayo, Inc. 1976). Experience has shown that survival rates have been a fraction of these assumed rates.

More recent scientific evidence about survival rates of hatchery reared salmon has given credibility to arguments cautioning the role of hatcheries. "The rapid decline of salmon runs throughout the Pacific Northwest has galvanized attention in the last 15 years. . . Recent scientific research suggests that hatcheries may have contributed to the decline of salmon runs." (Taylor 1996, abstract). "Yet artificial production has been implemented on a scale that will continue to commit a large percentage of the region's restoration resources, a large percentage of the available watersheds, and a large percentage of the remaining stocks to a single, unproven technology. There may be merit to reconsidering these practices." (Scientific Review Team 1999).

Table A-5
Hatchery and Marine Survival Egg Take to Emerge

Species	Heath Trays	Wash. Pond Trays	Gravel Box	Spawn Channel	Stream Improv.	Survival Per Month Reared Prior to Release	Marine Survival From Release to Return to Fishery	Weight at Release Number/ Pound
Fall chinook	80%	80%				98%	1.0%	90
Resident chinook	80%	80%				98%	10.0%	8
Spring chinook	63%	63%				98%	3.0%	8
Coho	75%	80%				98%	5.0%	20
Chum		75%				95%	1.5%	300
			75%				1.0%	1,200
					33%		1.0%	1,350
Pink			80%				3.0%	1,830
					33%		3.0%	1,830
Sockeye				60%			0.5%	1,500

Source: Kramer, Chin & Mayo, Inc. (1976).

The optimism of dependence on hatcheries:

> "From a social point of view, salmon enhancement is a highly desirable activity. . . From a biological point of view, salmon enhancement is feasible. There is potential in the ocean for growing more salmon." (Larkin 1974, p.1434).

turned to caution:

> ". . . the continued needs for protection of environment and a broadly balanced enhancement program with the appropriate amount of research and evaluation, there are some necessary changes in attitude concerning regulation. Under *no* circumstances should the permissible harvest of any race of salmon be exceeded. Day-to-day regulation should be geared to salmon biology, not human convenience." (Larkin 1979, p.98).

B. Oregon and Columbia River Hatchery Survival Rates

1. Oregon Hatcheries (Lewis 1995 and Lewis 1996)

Salmon produced in Oregon's hatcheries migrate to their feeding grounds in the Pacific. Coho salmon return after two years and chinook after three to five years. Survival from smolt to adult during their migration depends on many factors, from the size of the smolt at release, to inland habitat quality, ocean conditions, and fishing mortality. Total survival from smolt to harvest is estimated by using data from coded-wire-tags (CWT). Survival reports for hatchery produced coho and chinook are shown in Table A-6, Table A-7, and Table A-8.

Table A-6
Weighted Average Percent Survival of Coho Salmon Stocks Tagged for Stock Assessment /1

Stock Group		Brood Years	Overall Average Percent Survival	Percent Survival Range	1993 Brood Year Percent Survival	1984-1993 Brood Years Average	
						Ocean	Total
COLUMBIA RIVER COHO SALMON							
Sandy River	a	1977-1993	3.19	0.09 (1990) to 8.98 (1985)	0.32	1.53	3.24
Big Creek	a	1980-1993	2.82	0.21 (1990) to 8.12 (1986)	0.75	1.30	2.63
Bonneville Hatchery	a	1980-1993	2.48	0.42 (1992) to 6.92 (1986)	0.86	0.96	2.42
Klaskanine River	a	1981-1993	2.95	0.32 (1992) to 7.80 (1985)	0.51	1.18	2.41
Umatilla River		1985-1993	1.30	0.02 (1993) to 4.52 (1986)	0.02	0.65 /3	1.30 /3
Wahkeena Pond		1982-1992	1.45	0.00 (1985-87) to 7.17 (1983)	--	0.25 /3	0.88 /3
Yakima River		1986-1993	0.62	0.05 (1991) to 1.99 (1988)	0.08	0.38 /3	0.62 /3
Tualatin River		1991-1993	0.02	0.00 (1993) to 0.04 (1991)	0.00	0.01 /3	0.02 /3
COASTAL RIVERS COHO SALMON							
Rogue River	b	1977-1993	3.03	0.38 (1990) to 9.01 (1978)	4.04	0.55	2.59
Coos River	bd	1984-1993	2.35	0.22 (1993) to 7.88 (1985)	0.22	1.22	2.35
Nehalem River	bdf	1977-1993	1.62	0.37 (1992) to 6.22 (1985)	0.67	1.08	1.90
North Umpqua River	bdf	1980-1993	1.85	0.16 (1993) to 4.46 (1984)	0.16	1.22	1.56
Trask River	cdf	1977-1993	1.45	0.46 (1991) to 3.57 (1986)	0.52	0.89	1.51
Eel Lake		1980-1992	1.55	0.00 (1992) to 4.22 (1980)	--	0.73 /3	1.39 /3
Smith River		1976-86,1990-91	1.14	0.15 (1978) to 2.93 (1984)	--	1.23 /3	1.34 /3
Coquille River	cef	1980-1993	1.23	0.00 (1993) to 3.60 (1986)	0.00	0.60	1.20
South Umpqua R.	cef	1982-1993	1.15	0.08 (1992) to 4.10 (1985)	0.16	1.13	1.19
Alsea River	cef	1975-1993	1.94	0.24 (1993) to 5.90 (1978)	0.24	0.72	1.13
East Fork Trask R.		1983-1992	1.11	0.33 (1984) to 2.31 (1986)	--	0.72 /3	1.03 /3
Salmon River	ce	1976-1993	1.06	0.25 (1992) to 2.64 (1976)	0.40	0.22	0.49
Siletz River	e	1977-1993	0.98	0.09 (1992) to 2.72 (1980)	0.11	0.30	0.42
Siuslaw River		1986,1990-93	0.21	0.00 (1993) to 0.43 (1986)	0.00	0.16 /3	0.21 /3

Notes:
1. Percent survival includes both freshwater and ocean recoveries. Freshwater fisheries are only sampled in the Columbia River.
2. Survival (1984-1993 total survival) is not significantly different for stock groups followed by the same letter.
3. Does not include data from all ten years.

Source: Lewis (1997).

Table A-7
Weighted Average Percent Survival of Chinook Salmon Stocks Tagged for Stock Assessment /1

Stock Group		Brood Years	Overall Average Percent Survival	Percent Survival Range	1991 Brood Year Percent Survival	1982-1991 Brood Years Average: Ocean	1982-1991 Brood Years Average: Total
FALL CHINOOK SALMON							
Rogue River		1977-86, 1988-89, 1991	1.73	0.02 (1979) to 8.07 (1983)	0.13	2.19 /3	2.42 /3
Rogue River Columbia R. release	a	1982-1991	2.11	0.50 (1991) to 4.83 (1982)	0.50	1.26	2.11
Salmon River	a	1976-80, 1982-91	1.62	0.27 (1991) to 3.18 (1990)	0.27	0.60	1.73
Elk River	a	1977-1991	1.21	0.19 (1982) to 4.81 (1983)	0.56	1.01	1.41
Chetco River	a	1977-1991	1.38	0.08 (1988) to 3.20 (1985)	0.49	1.22	1.39
Coquille River		1983-88, 1990-91	1.01	0.04 (1991) to 4.06 (1985)	0.04	0.86 /3	1.01 /3
Coos River		1983-85, 1987-91	0.68	0.22 (1983) to 2.55 (1985)	0.61	0.41 /3	0.68 /3
Pistol River		1988-89, 1991	0.59	0.24 (1988) to 0.78 (1989)	0.74	0.49 /3	0.59 /3
Alsea River		1978-81, 1984-86, 1991	0.45	0.05 (1981) to 0.75 (1978)	0.20	0.34 /3	0.50 /3
Trask River	b	1982-1991	0.46	0.21 (1989) to 0.84 (1984)	0.24	0.29	0.46
Winchuck River		1988-89, 1991	0.36	0.10 (1988) to 0.74 (1991)	0.74	0.32 /3	0.36 /3
Nestucca River		1977-81, 1991	0.60	0.08 (1991) to 1.19 (1980)	0.08	0.04 /3	0.08 /3
South Umpqua River		1985, 1987-91	0.06	0.00 (1990-91) to 0.19 (1987)	0.00	0.06 /3	0.06 /3
SPRING CHINOOK SALMON							
Rogue River	c	1980-1991	2.23	0.47 (1988) to 5.19 (1983)	3.54	1.14	2.42
North Umpqua River	d	1976-1991	1.28	0.03 (1991) to 4.75 (1983)	0.03	1.23	1.30
Coquille River		1983, 1985, 1988-91	0.74	0.02 (1991) to 1.79 (1983)	0.02	0.67 /3	1.74 /3
Trask River	d	1977-1991	0.43	0.05 (1991) to 0.92 (1977)	0.05	0.23	0.39
Wilson River		1990-1991	0.24	0.08 (1991) to 0.39 (1990)	0.08	0.15 /3	0.24 /3
Nestucca River		1977-83, 1991	0.32	0.01 (1982) to 1.06 (1977)	0.11	0.03 /3	0.05 /3
South Umpqua River		1989-1991	0.00	0.00 (1989 & 91) to 0.01 (1990)	0.00	0.00 /3	0.00 /3
WINTER CHINOOK SALMON							
Trask River		1986-88, 1990-91	0.24	0.03 (1987) to 0.45 (1986)	0.19	0.16 /3	0.24 /3

Notes:
1. Percent survival includes both freshwater and ocean recoveries. Freshwater fisheries are only sampled for the Columbia River and Salmon River stock groups.
2. Survival (1982-1991 total survival) is not significantly different for stock groups followed by the same letter.
3. Does not include data from all ten years.

Source: Lewis (1997).

Table A-8
Weighted Average Percent Survival of Selected Columbia River Chinook Salmon Stocks /1

Stock Group	Brood Years	Overall Average Percent Survival	Percent Survival Range	1990 Brood Year Percent Survival	1984-1990 Brood Years Average		
					Ocean	Total	
FALL CHINOOK SALMON							
CEDC (Rogue Stock)	1984-87,1989	2.63	0.36 (1986) to 7.56 (1984)			2.63	/2
CEDC (Tule Stock)	1980-1987	0.29	0.04 (1987) to 1.68 (1984)			0.48	/2
Klaskanine (Tule)	1977-81, 1986-88	0.14	0.01 (1987) to 0.41 (1977)			0.08	/2
Big Cr. (Rogue)	1982-1990	2.28	0.71 (1990) to 4.84 (1982)	0.71		1.89	
Big Cr. (Tule)	1976-81, 1986-90	0.28	0.05 (1987) to 1.02 (1979)	0.07		0.12	/2
Bonneville (Tule)	1976-84, 1986-90	0.41	0.02 (1987) to 2.76 (1984)	0.10		0.57	/2
Bonneville (URB)	1977-1990	1.31	0.13 (1988) to 3.53 (1984)	0.15		1.17	
Stayton Pond (Tule)	1976-1990	0.57	0.09 (1986) to 3.41 (1984)	0.15		0.69	
SPRING CHINOOK SALMON							
Round Butte	1975-1990	0.84	0.04 (1976) to 1.93 (1986)	0.27		1.28	
West Fork Hood River	1986-1990	0.13	0.01 (1990) to 0.33 (1986)	0.01		0.13	/2
Willamette	1974-75, 77-80, 84-90	1.15	0.24 (1975) to 2.36 (1978)	0.31		0.98	
McKenzie	1978-81, 1984-90	0.81	0.05 (1990) to 1.61 (1981)	0.05		0.81	
South Santiam	1975-78, 84-85, 87-90	0.62	0.20 (1990) to 1.38 (1985)	0.20		0.77	/2
Marion Forks	1974-77, 79-80, 82-90	0.76	0.01 (1974) to 1.82 (1986)	0.08		1.06	
Clackamas	1984-1990	0.50	0.07 (1985) to 1.17 (1988)	0.25		0.50	
CEDC (SF Klaskanine)	1988-1990	0.01	0.00 (1990) to 0.04 (1989)	0.00		0.01	/2
CEDC (Youngs Bay)	1988-1990	0.20	0.05 (1990) to 0.44 (1988)	0.05		0.20	/2

Notes: 1. Percent survival includes both freshwater and ocean recoveries.
2. Does not include data from all seven years.

Source: Lewis (1995).

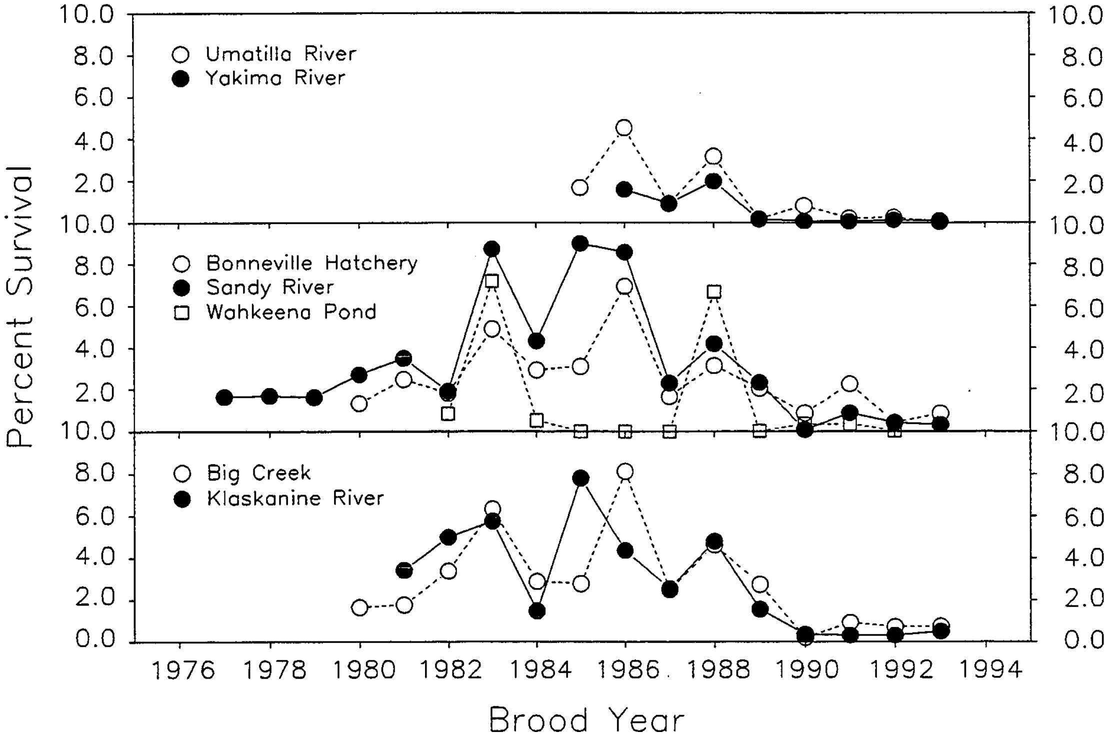
Survival rates vary a great deal. For example, Oregon coastal coho adult ocean survival rates of three to six percent were common in the late 1960's through the mid 1970's. Since then, survival has only been 1.5 percent or less. In the Columbia River, the coho survival was above four percent during the 1980's and seems to have dropped to less than one half percent since 1990.

2. Columbia River Hatcheries

In addition to the Oregon reports on survival rates, the Bonneville Power Administration funds the collection of survival rate and catch rate information on Columbia River Basin produced salmon. These are generally called the "missing production groups" reports or the IHOT reports. The Columbia River Basin hatchery releases may be segregated into five general areas from the lower Columbia River to the Snake River. The best estimates of survival rates that represent the last 20 to 30 years of production for these areas, utilizing the Pastor (1995, 1996), Garrison et al. (1995), and Fuss et al. (1994) data for these areas, are shown in Table A-9, Figures A-7 and A-8.

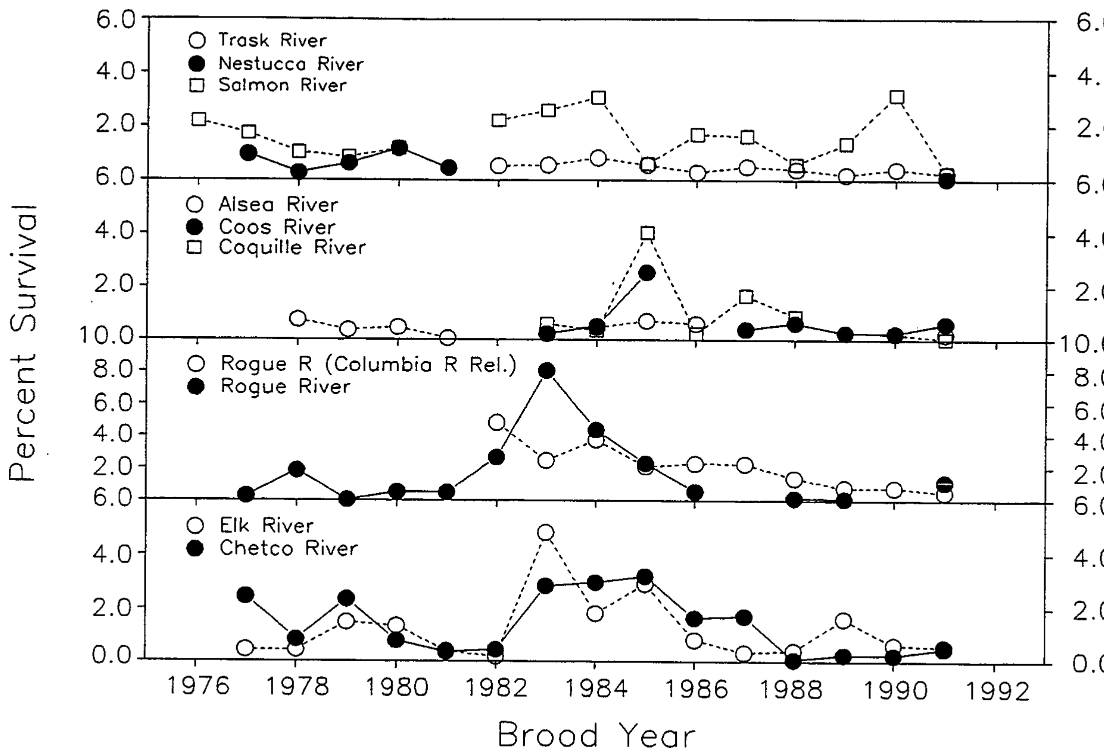
These should be considered representative survival rates for species released at various areas of the Columbia River Basin and what may be expected under fairly good freshwater and ocean survival. One year variation may misrepresent average expected survival rates over time. Care has to be taken when using averages, medians, or perhaps even representative rates. Survival rates should be used in the context of what may be expected during the years of interest. Figure A-9 shows the wide variations that may be expected in a range of about twenty years.

Figure A-7
Weighted Average Percent Survival of Columbia River Coho Salmon Stocks Tagged for Stock Assessment



Source: Lewis (1997).

Figure A-8
Weighted Average Percent Survival of Fall Chinook Salmon Stocks Tagged for Stock Assessment



Source: Lewis (1997).

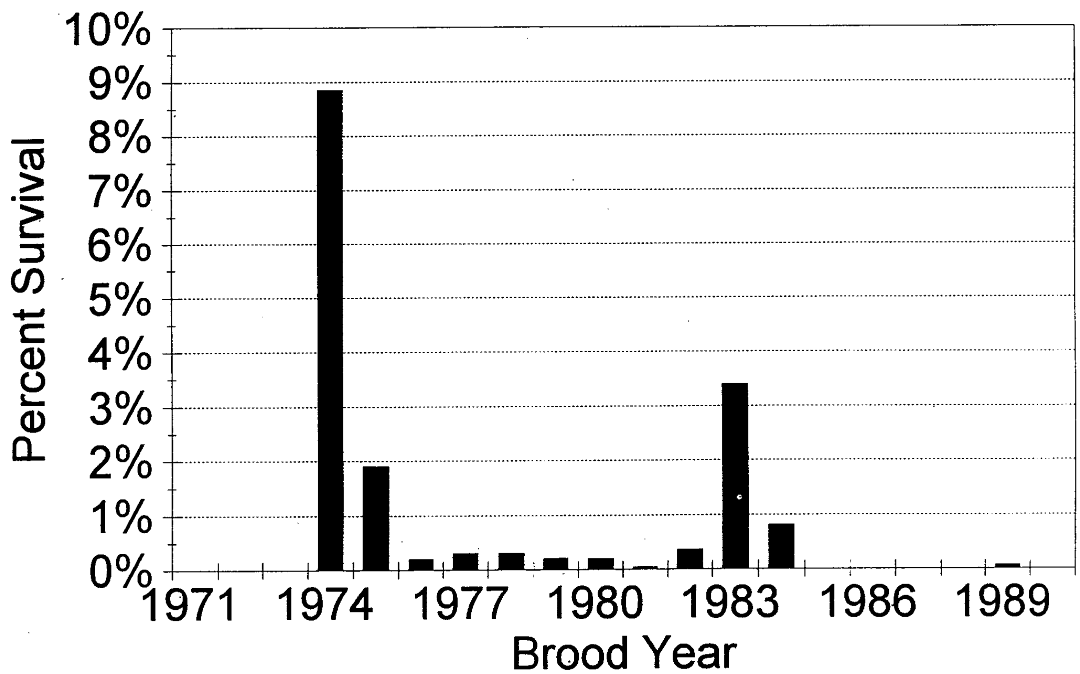
Table A-9
Areas of Releases and Representative Recent (30 Year Average)
Survival Rates of Hatchery Fish in the Columbia River Basin

	Species and Average Survival Rates (Percent)			
Area of Release	Spring Chinook	Fall Chinook	Coho	Steelhead
Willamette	0.97	--	1.20	0.40
Lower Columbia	0.97	0.32	2.50	0.40
Middle Columbia River	0.37	0.60	1.20	0.70
Upper Columbia River	0.37	0.60	1.20	0.70
Snake River	0.37	0.60	--	0.70

Note: The size of the coho is about 12 smolts per pound, while spring chinook averaged about nine per pound. About 10 percent of the fall chinook are released as smolts that average about 15 per pound. These "large" smolts survive at rates from one percent to 1.75 percent rate. The smaller smolts, which are about 60 percent of smolt releases from the Columbia River system, survive at about a 0.30 percent rate.

Source: Pastor (1995, 1996), Smith (1998), and Study.

Figure A-9
Columbia River Fall Chinook, Grays River Hatchery



Source: Fuss (1994).

CHAPTER IV. PERSPECTIVE ON THE HISTORICAL ECONOMIC VALUE OF COLUMBIA RIVER ANADROMOUS FISH HARVESTS

A. Commercial and Recreational Fisheries for All Marine Species Along the West Coast of North America

Improved harvesting and processing technology have expanded ocean harvests of marine species along the west coast of North America. The lure of exploiting natural resources, including fish, provided investment capital and human resources. There are few undeveloped fisheries and nearly all species are fished at maximum sustainable yields.

Including all species (such as groundfish), commercial and recreational fishing generated an annual total of about $7.5 billion in regional economic impacts (RED benefits) in 1994 (Table A-10 and Figure A-10). At an average full time equivalent job of $25,000 per year earnings, this is equal to about 300,000 jobs (Table A-11 and Figure A-11). The fisheries off Alaska waters generate the most personal income, about 73 percent of the total or about $5.4 billion.

Groundfish harvesting and processing contribute more than half of total regional economic impacts (RED benefits) from marine resources along the west coast of North America, or about $4 billion. Commercial salmon fishing, especially in Alaska, generates about 22 percent or about $1.7 billion and supports about 67,000 jobs.

Recreational fishing for salmon and steelhead generated about $0.8 billion in regional economic impacts (RED benefits). Of this amount, recreational fishing in Alaska and British Columbia contributed about 25 percent (four percent in Alaska and 21 percent in British Columbia), while recreational fishing in Washington, Oregon, and California generated about 15 percent each.

Although fishing is very important for some coastal communities on the west coast of North America, commercial marine fishing including recreational angling for salmon and steelhead generates less than one percent of total personal income. As leisure time has increased, the personal income generated from recreational fishing is becoming a more important component of total personal income than commercial fishing in many coastal communities.

B. Regional Economic Impacts (RED Benefits) From Anadromous Fish Runs

1. Historical Columbia River Anadromous Fish Runs

Historically, all salmon were wild fish produced in the natural stream environment. The NPPC concluded that up to 16 million fish run size is the most reasonable estimate of Columbia River historic runs (NPPC, March 1986). A 50 percent harvest rate of these runs (mostly summer and spring chinook) could have supported a one half billion dollar industry (Table A-12) (Radtke and Davis, January 1996).

Table A-10
Representative Annual Harvests of Major Marine Resources in Recent Years and Resulting Estimated Regional Economic Impacts (RED Benefits) Along the West Coast of North America

Region	Major Species	Pounds or Angler Days (in 1,000's)	Regional Economic Impacts (in 1,000's)	Percent By Region	Percent By Species
Alaska	Salmon	800,000	1,207,000		22%
	Shellfish	126,500	425,000		8%
	Herring	150,000	150,000		3%
	Groundfish	4,040,000	3,400,000		63%
	Recreational (salmon/steelhead only)	1,925	205,000		4%
	Total Economic Contribution	5,118,425	5,387,000	72%	
British Columbia	Salmon	150,000	353,100		38%
	Shellfish	25,000	55,500		6%
	Herring	65,000	70,500		8%
	Groundfish	325,000	258,000		28%
	Recreational (salmon/steelhead only)	5,970	191,000		21%
	Total Economic Contribution	570,970	928,100	12%	
Washington	Salmon	34,000	69,600		18%
	Shellfish	35,000	80,000		20%
	Tuna	5,000	8,000		2%
	Groundfish	165,150	100,750		26%
	Recreational (salmon/steelhead only)	4,180	134,000		34%
	Total Economic Contribution	243,330	392,350	5%	
Oregon	Salmon	5,000	17,100		4%
	Shellfish	35,000	66,900		17%
	Tuna	5,000	8,000		2%
	Groundfish	300,150	175,750		46%
	Recreational (salmon/steelhead only)	3,660	116,600		30%
	Total Economic Contribution	348,810	384,350	5%	
California	Salmon	5,000	18,300		5%
	Shellfish	45,000	75,500		19%
	Tuna	100,000	70,000		17%
	Herring etc.	110,000	66,000		16%
	Groundfish	60,000	72,000		18%
	Recreational (salmon/steelhead only)	1,930	103,000		25%
	Total Economic Contribution	321,930	404,800	5%	
Idaho	Recreational (steelhead only)	300	8,800		100%
	Total Economic Contribution	300	8,800	0%	
Total	Salmon	994,000	1,665,100		22%
	Shellfish	266,500	702,900		9%
	Herring, tuna, etc.	435,000	372,500		5%
	Groundfish	4,890,300	4,006,500		53%
	Recreational (salmon/steelhead only)	17,965	758,400		10%
	Total Economic Contribution	6,603,765	7,505,400	100%	

Table A-10 (continued)

Notes: 1. RED benefits expressed in thousands of 1994 U.S. dollars.

2. A recent study by Reading (1999) analyzed the regional economic impacts for trip and equipment expenditures from the 1992-1993 steelhead fishery in Idaho and a hypothetical salmon fishery. The results are not comparable due to differences in methods and data. For example, the table shows only personal income generated by trip expenditure effects, while Reading (1999) expresses impacts as business sales and includes equipment expenditures.

3. Data and Regional Economic Impact Models

Data of harvests and recreational angling trips are taken from three basic sources. These are:

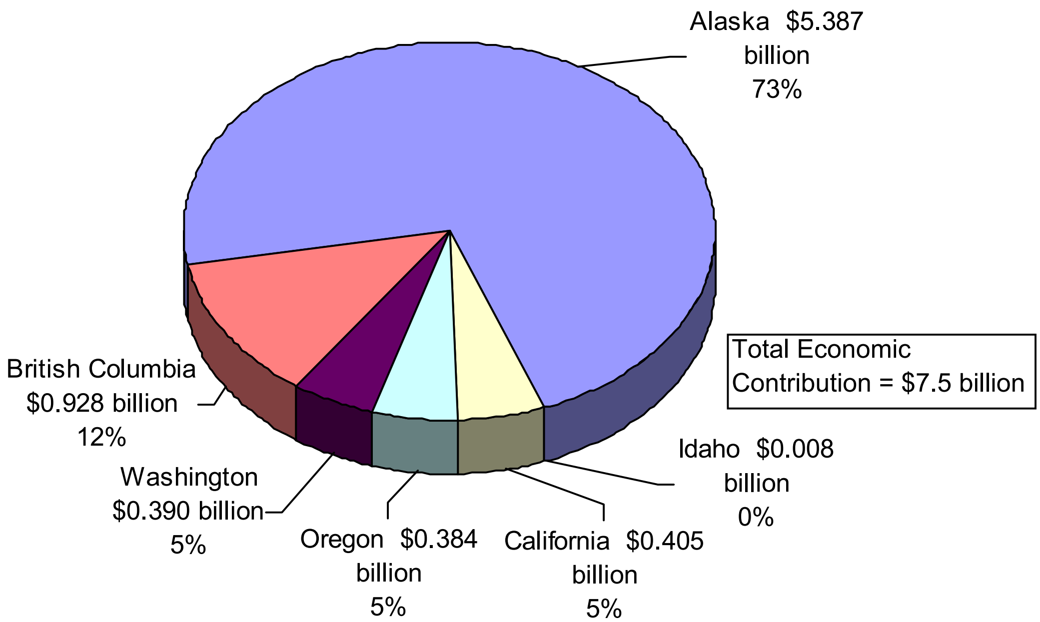
- Pacific Fishing Magazine, "Annual Stats Pack," Seattle, Washington
- Pacific States Marine Fisheries Commission, "Annual Reports," Gladstone, Oregon
- National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (Alaska, Washington, Oregon, California, and Idaho), U.S. Department of the Interior, U.S. Fish and Wildlife Services, 1991

The basic model for estimating the economic contribution is the Fisheries Economic Assessment Model (FEAM), originally developed by Hans Radtke and William Jensen for the West Coast Fisheries Development Foundation and now used by agencies such as the PFMC and ODFW. For an explanation, please refer to:

- The Research Group, Oregon Angler Survey and Economic Impact Analysis, prepared for ODFW, June 1991
- Hans Radtke and Shannon Davis, The Economics of Ocean Fishery Management in Oregon, prepared by prepared for Oregon Coastal Zone Management Association, Inc., 1994
- Review of Ocean Salmon Fisheries (annual reports), PFMC, Portland, Oregon

Source: Radtke (May 1997).

Figure A-10
Regional Economic Impacts (RED Benefits) of Marine Harvests
Along the West Coast of North America by Region



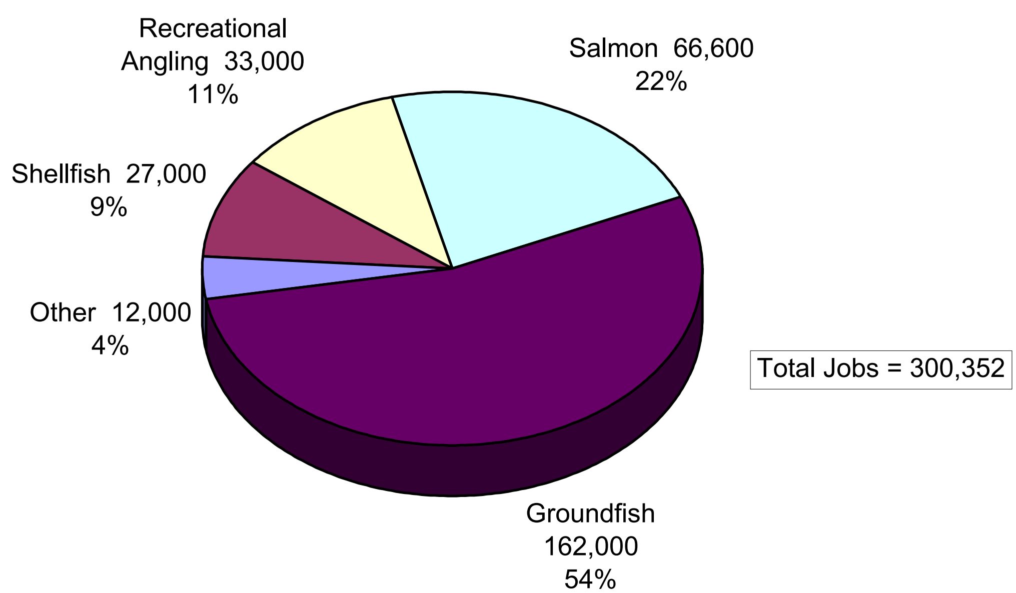
Note: Shares are representative of recent years' harvests.
Source: Radtke (May 1997).

Table A-11
Regional Economic Impacts (RED Benefits) and Jobs
From Fishing Along the West Coast of North America

Area	Percent of Total	Regional Economic Impacts	Jobs
Alaska	73%	5.4	216,000
British Columbia	12%	0.9	36,000
Washington	5%	0.4	16,000
Oregon	5%	0.4	16,000
California	5%	0.4	16,000
Idaho	0%	0.008	352
Total	100%	7.5	300,352

Notes: 1. RED benefits expressed as personal income per year in billions of 1994 U.S. dollars.
2. Job estimates assume $25,000 average earnings per job.
Source: Radtke (May 1997).

Figure A-11
Fishing Industry Jobs Supported by Commercial Fishing and Recreational Angling



Note: Job shares are representative of harvests in 1994.
Source: Radtke (May 1997).

Table A-12
Estimated Historic, Pre-Development Salmon and Steelhead Run Size of the Columbia River System and Resulting Annual Potential Ex-Vessel Revenues, Regional Economic Impacts, and Jobs

Species	Total Number of Fish (thousands)	Average Weight Per Fish in Pounds	Total Pounds (thousands)	Price	Ex-Vessel Revenues at 50% Harvest Rate (thousands)	Regional Economic Impacts Per Pound in $	Regional Economic Impact at 50% Harvest Rate (thousands)	Estimated Total Full Time Equivalent Annual Jobs at $20,000 per Year - Range
Spring chinook	2,300	20	46,000	3.25	74,750	5.75	132,250	6,613
Summer chinook	4,600	20	92,000	3.25	149,500	5.75	264,500	13,225
Fall chinook	2,300	20	46,000	1.00	23,000	2.20	50,600	2,530
Coho	1,780	9.0	16,020	1.00	8,010	2.20	17,622	881
Sockeye	2,600	3.5	9,100	2.00	9,100	3.75	17,063	853
Chum	1,392	12	16,704	0.60	5,011	1.75	14,616	731
Steelhead	1,348	8.5	11,458	0.60	3,437	1.75	10,026	501
Total	16,320		237,282		272,808		506,677	25,334

Notes:
1. Total number of fish from NPPC (1986), pp.18-19.
2. Price is representative 1994 dollars. These represent recent years prices for salmon harvested in the Columbia River. In the world salmon market, regional salmon production should be considered a commodity. Spring and summer chinook having timing and quality characteristics that command attractive prices.
3. Ex-vessel revenues at 50 percent harvest rate in most years with healthy stocks is considered a sustainable harvest rate.
4. Regional economic impacts (RED benefits) expressed as personal income.

Source: Radtke (May 1997).

The internal combustion engine has contributed to changes in the harvesting of salmon that originate in the Columbia River. As early as 1910 trollers ventured out in the open ocean off Washington and Oregon in order to harvest salmon over a longer period of the year. Much of the fisheries that harvest Columbia River produced salmon now take place in ocean fisheries (troll as well as net) from southeast Alaska to Northern California.

The salmon that swim in the river today differ fundamentally from those of the aboriginal Columbia. The pre-European development salmon runs were predominantly spring and summer chinook on their way to spawn in the upper reaches of the Columbia River system. As compensation for the loss of wild salmonid production, many artificial propagation hatcheries were built throughout the Columbia River Basin. Artificial production now accounts for about two thirds to three quarters of all fish returning to the Columbia River system (WDFW and ODFW 1996). Past production and management policies that were designed to be based on hatchery operation may not be meeting expectations of producing fish for harvest and may be incompatible with protecting existing wild stocks.

Most of the fish returning to the mouth of the river today are coho or “tule” chinook released at lower Columbia hatcheries. The origin of salmon stocks in pre-development runs was about 77 percent Upper River to 23 percent Lower River, whereas the origin of the 1977-1981 salmon runs was 58 percent Lower River and 42 percent Upper River (Figures A-3a and A-3b) (Lee 1993, p.25).

NMFS has imposed a “cap” on hatchery production of 197 million fingerling and smolt annual releases (Table A-2) (U.S. Department of Commerce 1995). Hatchery production has been about 130 million fingerlings and smolts in recent years (Smith 1998). The assumption for the John Day pool water management alternative analysis is that hatchery production in the Columbia Basin will not change.

Unless there are fundamental changes to Columbia River production, it has to be assumed that any dramatic increases in adult salmon returns will result from improved hatchery practices and downriver and ocean survival. Improvements to hatchery practices may allow natural production to be "supplemented" with artificial propagation practices that are integrated into the functioning of the entire ecosystem. Increases in returns from wild origin anadromous fish, such as through freshwater habitat improvements, will assist in the John Day Pool area to restoration of historical fisheries.

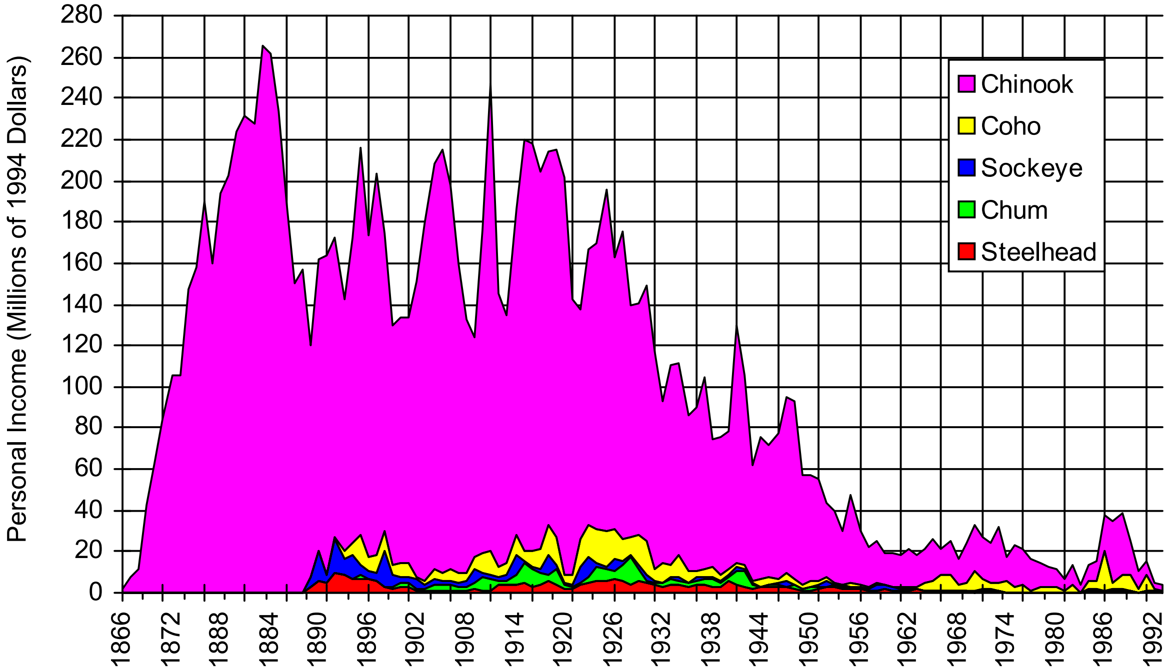
2. Example Regional Economic Impacts (RED Benefits) From Salmon and Steelhead Fishing on Coastal Communities

The changing nature of salmon harvests and their regional economic impact may best be illustrated by showing the effects on a coastal community, such as Astoria, Oregon. During the late 1880's and early 1920's, the salmon gillnet fishery in the Columbia River pumped a substantial amount of income into the Astoria area. At today's prices (reflecting 1998 price levels), these runs contributed as much as $260 million in regional economic impacts (RED benefits) into this area (Figure A-14). This would support about 10,000 to 13,000 jobs. During these early years of development, salmon was the most important sector in the area's economy. Personal income received by residents along the lower Columbia River in the years between 1987 and 1992 averaged about $29 million (PFMC 1997) from commercial gillnet and recreational salmon fishing. However, since 1993, because of very poor survival rates of hatchery fish, the personal income generated from salmon fisheries in the lower Columbia River has declined to about $2 million (Table A-13). Total personal income in the Astoria area (Clatsop County) was $684 million in 1996 (Oregon Employment Department 1998). All commercial fishing generated an estimated $70 million. Commercial fishing is about 10 percent of the local area, while salmon fishing in the Columbia River at the present time generates about 0.2 percent of the personal income in this area. This is a small share of what may have been generated with historic salmon runs.

3. Change to Anadromous Fish Hatchery Based Production

The hatchery salmon smolt production cap as proposed in March 1995 by the NMFS, at representative mid-1980's smolt to adult survival rates, may generate about $74 million in regional economic impacts (RED benefits) from hatchery smolt releases. Another $9 million could be expected from wild salmon harvests for a total of $83 million. In order to have eight million adult fish harvested (the historic harvests) out of the hatchery and wild fish smolt production (246 million smolt total), the smolt to adult survival rates would have to be about three percent overall. The 1980's survival rates of hatchery fall chinook releases (majority of releases) were 0.3 percent in good ocean conditions and are about 0.03 percent at the present.

Figure A-14
Historical Columbia River Estimated Regional Economic Impacts (RED Benefits)



Sources: Landing data are from NPPC (1986), fish size and ex-vessel price are from ODFW (1995), and regional economic impacts (RED benefits) per pound in 1994 U.S. dollars are from Radtke (May 1997).

Table A-13
Regional Economic Impacts (RED Benefits) From Commercial Salmon Gillnet and Recreational Lower Columbia Fisheries from 1987 to 1996

	Years				
	1987-1992 Average	1993	1994	1995	1996
Commercial gillnet	23,101	2,092	2,019	956	1,389
Lower Columbia recreational	6,332	4,879	3,036	379	999
Total	29,433	6,971	5,055	1,335	2,388

Note: RED benefits expressed as personal income in thousands of 1996 U.S. dollars.
Source: Radtke (May 1997).

Therefore, by changing to hatchery based production, the Columbia River system will not be able to again generate the $200 million to $500 million of personal income it once generated. This, of course, may change if the wild fish resource were to be returned to its historic levels by remedying habitat alterations and hydrosystem problems.

4. Change to Ocean Mixed Stock Fisheries

Historically, harvesters waited until adults returned to the Columbia River to harvest salmon. Today, salmon produced in the Columbia River system are harvested from California to Alaska by trolling gear and by nets set to harvest other species of salmon, and are caught incidentally in other ocean fisheries.

In recent years, the Columbia River economy only received a portion of the personal income generated by each salmon hatched and reared in the Columbia River system. For example, out of 100 released fall chinook smolts, the Columbia River area economies may receive $7.30 of personal income out of a total of $22.05 generated (Table A-14). From both hatchery and wild origin smolt production during the 1980's, the Columbia River communities may only receive about 46 percent of the of the regional economic impacts (Figure A-15).

About half of the Columbia hatchery smolt releases are presently fall chinook. Most of these salmon will be harvested in other geographic areas, not in the Columbia River. This is a direct result of the growth of the ocean troll mixed stock specie fishery and a hatchery production program that produced fall chinook salmon that moved close to the Washington shore on their return to the Columbia River. Therefore, hatchery practices have resulted in a shift of personal income generated from the Columbia system to other geographic areas.

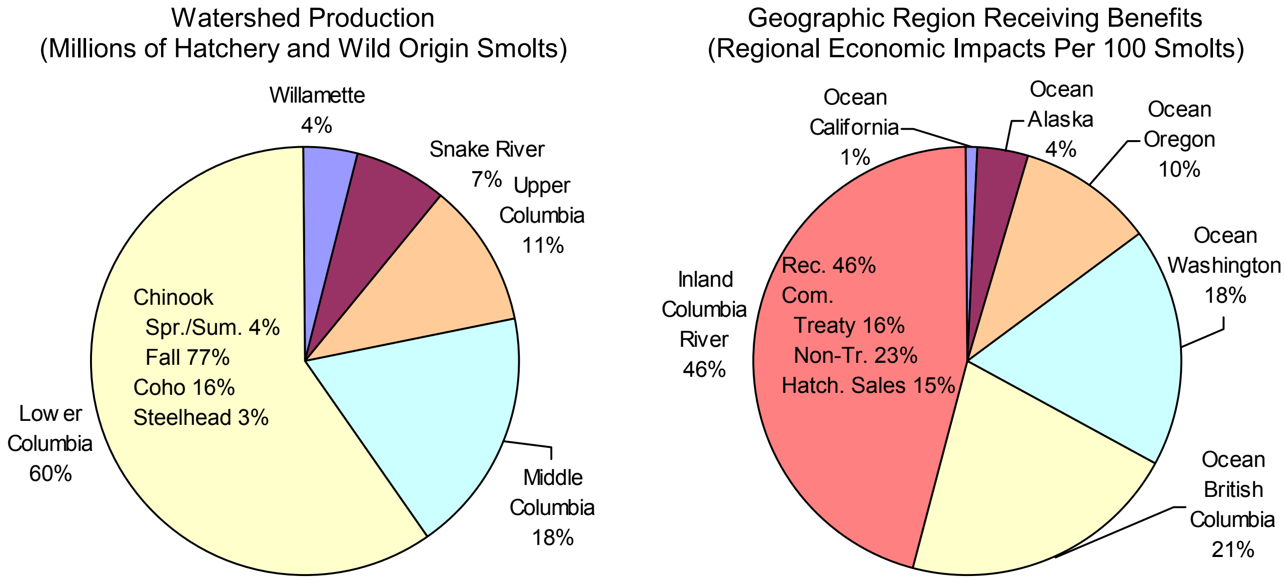
Table A-14
Estimated Regional Economic Impacts (RED Benefits) From the Columbia River Basin Hatchery System Produced Salmon by Species and Geographic Regions

Species	Survival Rate	Hatchery Smolt Releases	Columbia River Region Hatchery Impacts	Other Region Hatchery Impacts	Total Hatchery Impacts
Coho	2.72%	35,325,745	22.56	54.39	76.95
Spring/summer chinook	0.69%	27,392,626	19.77	10.17	29.95
Fall chinook	0.49%	113,802,184	7.30	14.75	22.05
Steelhead	1.38%	20,042,061	59.05	0.36	59.41
Total		196,562,616	17.06	19.77	36.83

Notes:
1. Regional economic impacts (RED benefits) expressed as personal income in 1998 dollars per 100 released smolts.
2. Analysis assumes representative 1980's survival rates and hatchery production.
3. The table includes all spring chinook releases. These survival rates and area of catch may represent the Willamette stocks more than the upper Columbia and Snake. Upper Columbia and Snake in recent years have not survived at these rates nor have they been harvested in the open ocean.

Source: Study.

Figure A-15
Shares of Columbia River Basin Anadromous Fish Production and Geographic Regions Receiving Regional Economic Impacts (RED Benefits) From the Production



Notes: 1. Wild and hatchery origin smolt production is representative of the 1980's.
2. The regional economic impacts for the inland Columbia River Basin region include inriver treaty and non-treaty commercial fisheries, inriver recreational fisheries, and hatchery return sales.

Source: NMFS (1995) and Study.

CHAPTER V. POTENTIAL ECONOMIC VALUES FOR FOUR CASES OF COLUMBIA RIVER BASIN ANADROMOUS FISH PRODUCTION AND HARVEST MANAGEMENT POLICIES

This chapter describes the potential economic value to the region and nation that may result from four cases of anadromous fish production and harvest management policies. The four cases are selected to give a range of what may happen in the future. The results are a broad overview of the regional economic impacts and net economic values that may happen depending on conditions and actions to improve anadromous fish runs. The results may also be viewed as what is at risk if the Columbia River Basin salmon and steelhead are allowed to be extirpated.

A. Methods Used to Determine Columbia River Basin Anadromous Fish Harvests

1. Representative Survival Rate Estimates Used to Forecast Columbia River Basin Harvest

For almost all species and stocks, Columbia River anadromous fish survival rates have steadily decreased since the mid 1980's. There are many theories about the decrease, from hatchery practices to ocean conditions. For this study, the expected survival of wild runs in the Snake River system is taken from PATH results. For evaluation of the production from the Columbia River Basin, as described under four cases of Columbia River anadromous fish production and harvest management policies, representative survival rates for three periods are used: the past 30 years, the 1980's, and the early 1990's. Table A-15 shows the survival rates by area and species. For example, based on the National Marine Fisheries Service (NMFS) cap releases of 197 million smolt releases, a total of 1.59 million smolts may survive to adults from hatchery releases (Table A-16).

2. Hatchery and Wild Smolt Production

For hatchery origin fish, at least two spawners (one male and one female) are required for future egg and smolt production. Each coho salmon and steelhead female spawner produces about 2,500 eggs, while chinook produce 3,500 or more eggs. Hatchery egg-to-smolt survival tends to be about 80 percent. In order to provide some flexibility in hatchery spawner requirements, three future returning spawners per spawning pair are used in calculations of this report. Other fish returning to the hatchery are assumed available for sale as fresh, frozen, or processed product. Total survival from smolt-to-adult will determine the amount available for harvest and those returning to the hatchery.

For wild origin fish, the assumption is wild spring/summer chinook and steelhead contribute an additional 30 percent to the total salmon runs of the Columbia River Basin, while wild fall

Table A-15
Smolt-to-Adult Survival Rate Assumptions by Area and Species Used For Four Cases of Production and Harvest Management Policy in the Columbia River Basin

	Snake River	Upper Columbia	Middle Columbia	Lower Columbia	Willamette	Weighted Average
Coho						
I. NMFS Cap (1970's-1990's Actual)	NA	1.20%	1.20%	2.50%	1.20%	2.33%
II. 80's Actual Runs	NA	1.49%	1.49%	2.90%	1.49%	2.72%
III. Run Doubling Objective	NA	2.98%	2.98%	5.80%	2.98%	5.43%
IV. Early 90's Runs	NA	0.15%	0.15%	1.00%	0.40%	0.90%
Spring/Summer Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.37%	0.37%	0.37%	0.97%	0.97%	0.65%
II. 80's Actual Runs	0.39%	0.39%	0.39%	1.01%	1.02%	0.69%
III. Run Doubling Objective	0.79%	0.79%	0.79%	2.03%	2.04%	1.37%
IV. Early 90's Runs	0.10%	0.10%	0.10%	0.35%	0.35%	0.22%
Fall Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.60%	0.60%	0.60%	0.32%	NA	0.41%
II. 80's Actual Runs	0.73%	0.73%	0.73%	0.38%	NA	0.49%
III. Run Doubling Objective	1.45%	1.45%	1.45%	0.77%	NA	0.99%
IV. Early 90's Runs	0.40%	0.40%	0.40%	0.25%	NA	0.30%
Steelhead						
I. NMFS Cap (1970's-1990's Actual)	0.70%	0.70%	0.70%	0.40%	0.40%	0.62%
II. 80's Actual Runs	1.56%	1.56%	1.56%	0.89%	0.89%	1.38%
III. Run Doubling Objective	3.11%	3.11%	3.11%	1.78%	1.78%	2.76%
IV. Early 90's Runs	0.50%	0.50%	0.50%	0.20%	0.20%	0.42%

Notes:
1. Rates expressed as representative percents of hatchery reared smolts released divided by adults contributing to fisheries plus adults returning to hatcheries. Survival rates are best estimates based on information provided by the "Annual Coded Wire Program - Missing Production Groups" annual reports (Fuss et al. 1994 and Garrison et al. 1995).
2. Survival rate assumptions for the "Run Doubling Objective" case are the survival rates that would be required to meet the objectives.

Source: Study.

Table A-16
Estimated Total Released Hatchery Smolts Based on NMFS
Cap of 197 Million and Representative 1990's Survival Rates

	Fall Chinook		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	612,797	0.60	3,677
Upper Columbia	12,329,885	0.60	73,979
Lower Columbia	76,857,203	0.32	245,943
Middle Columbia	24,002,299	0.60	144,014
Willamette	--	--	--
Total	113,802,184		467,613

	Spring/Summer Chinook		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	2,342,791	0.37	8,668
Upper Columbia	5,990,957	0.37	22,167
Lower Columbia	5,253,481	0.97	50,959
Middle Columbia	6,264,260	0.37	23,178
Willamette	7,541,137	0.97	73,149
Total	27,392,626		178,120

	Coho		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	--	1.20	--
Upper Columbia	843,373	1.20	10,120
Lower Columbia	30,742,613	2.50	768,565
Middle Columbia	2,462,651	1.20	29,552
Willamette	1,277,108	1.20	15,325
Total	35,325,745		823,563

	Steelhead		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	12,900,795	0.70	90,306
Upper Columbia	1,363,636	0.70	9,545
Lower Columbia	3,775,119	0.40	15,100
Middle Columbia	536,886	0.70	3,758
Willamette	1,465,625	0.40	5,863
Total	20,042,061		124,572
Total	196,562,616		1,593,868

Source: Smith (1998) and Study.

chinook contribute about 50 percent of the run.[1] For coho, the wild to hatchery rate is about five percent.

For coho and steelhead, at survival rates of 0.01, about 25 adults will have survived from a pair of spawners (three spawners are used in this analysis to allow for egg to smolt mortality and other unforeseen factors). Therefore, 12 percent of adults are required for hatchery purposes. At 0.005, this increases to 24 percent, etc. For chinook, the requirement at 0.01 survival is 8.6 percent and 17 percent at 0.005 percent.

3. Distribution to Fisheries

There are three basic distribution patterns of Columbia River Basin produced salmon: north turning fish (fall chinook), south turning fish (coho), and some that tend to migrate in either direction (some of the above). Steelhead tend to scatter and migrate as far as Russian waters. Harvest rates by geographic area depend on migration patterns, as well as historic fishing patterns, and on international and historic treaties and management policies. The same reports used in calculating survival rates are used to calculate geographic and user group harvests. The distributional assumptions are that future harvests will reflect recent historical catches. These assumptions, however, depend on present U.S. - Canada and treaty tribal allocations. Columbia River treaty allocation represents the amount that may be harvested by treaty fisheries after harvests north of the U.S./Canada border and hatchery requirements are met. In the case of spring/summer chinook, only the "doubling of the runs" case will return sufficient returning fish to allow a 50 percent take by treaty fisheries. Within these components, historical and expected allocations are calculated.

4. Economic Values

The economic values are itemized by commercial and recreational fisheries and the area where fish are harvested. Two important economic assumptions are that hatchery surplus is utilized in the commercial sector and that wild and hatchery fish survive and are harvested at similar rates. A discussion of the importance of these assumptions is included in the risk and uncertainty section.

B. Potential Economic Values

1. Background

In the 1980's, the concern for decreasing Columbia River Basin salmon runs was the basis for the NPPC's interim goal of doubling salmon populations. The overall effect of hatchery fish on the survival of certain anadromous species has led to the NMFS placing a cap on the total hatchery releases in the Columbia River System. Because hatchery and wild fish cannot

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1. The ceiling may be viewed as a limit to present hatchery releases, using present hatchery management practices. Supplementation practices based on species specific, habitat based practices may increase wild stock production. These same practices, that alter the water resources of the Columbia River Basin, may also increase the survival rates of hatchery based production.

always be separated during harvesting, hatchery production and harvest management directly affect the existing wild salmon runs. In recent years, for every two wild spawners from the Snake River system, about 1.2 spawners return in subsequent cycles (Smith 1998). The low rate of returning wild spawners has raised concerns about maintaining and recovering any wild salmon species in the upper Columbia Basin, especially in the Snake River system. Strategies for recovery may be habitat based, hatchery based, or a combination of both. However, a strategy based on artificial propagation with no increase in natural production would, over time, result in higher annual hatchery costs (Smith 1999).

In order to estimate the total potential economic value of salmon produced in the entire Columbia River Basin, four policy cases are assumed. These are the production of the 1980's, a doubling of these levels, and a NMFS cap on the amount and species released from hatcheries in the Columbia River Basin. A case is also included that includes the low survival rates of the 1990's. Two of these cases may be viewed as goals or policies that have been presented. The other two, the 1980's and 1990's cases, reflect recent actual conditions.

The ability to harvest salmon has an important economic value to people of the Pacific Northwest and to the nation. Historically, salmon have been a part of the economy and culture of the people of the Pacific Northwest. To the Indians living along the Columbia River, salmon were their lifeblood, essential to their subsistence, their culture, and their religion. Salmon today also play an important part in the lives of most citizens of the Pacific Northwest. These values can be defined as option or existence values. These may be considerable, but are not included in these evaluations. The fishing values in this section only estimate commercial and recreational economic value of what may show up in economies. The economic value of non-use (option or existence value) placed on these fish runs may be much higher than the values that can be shown as contributing to economies.

2. Potential Regional Economic Impacts (RED Benefits)

The regional economic impact (RED benefits) results may be viewed as the value of what may be lost to the region if survival rates are not increased. The potential regional economic impacts (RED benefits) of harvestable fish under the first three cases ranges from $83 million under the NMFS cap case to $233 million per year (Table A-17). The latter assumes that "doubling of the runs" may be achieved. The fourth case includes the survival rates that are being experienced in the 1990's. At these low survival rates, with present hatchery smolt releases, the regional economic impacts (RED benefits) throughout the region would total $38 million per year. The hatchery surplus utilization is an important assumption for spring/summer chinook and steelhead, where up to 30 percent of the regional economic impacts (RED benefits) may be derived from commercial utilization of surplus hatchery fish.

Potential economic contribution by geographic area for the four cases is displayed graphically in Figure A-16. The size of the portrayed fish is proportionally correct to the economic contribution. Fall chinook, even though they survive at lower rates, are released at greater

Table A-17
Regional Economic Impacts (RED Benefits) of Columbia River Basin Produced Salmon/Steelhead by Geographic Areas For Four Cases of Production and Harvest Management Policies

	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Coho								
Alaska	172	0.0%	200	0.0%	399	0.0%	57	0.0%
British Columbia	931,431	3.8%	1,082,468	3.8%	2,164,937	3.7%	304,729	4.2%
Washington ocean	7,932,510	32.5%	9,312,546	32.5%	19,074,457	32.6%	2,337,418	32.2%
Washington Puget Sound	31,107	0.1%	36,337	0.1%	74,329	0.1%	9,520	0.1%
Oregon	7,870,260	32.3%	9,229,961	32.3%	18,900,175	32.3%	2,337,581	32.2%
California	477,110	2.0%	564,282	2.0%	1,158,039	2.0%	132,474	1.8%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,449,256	10.0%	2,863,341	10.0%	5,858,368	10.0%	745,099	10.3%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	3,413,032	14.0%	3,992,654	14.0%	8,170,337	14.0%	1,033,242	14.3%
Tribal	277,742	1.1%	353,124	1.2%	737,882	1.3%	5,842	0.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	794,035	3.3%	933,697	3.3%	1,913,269	3.3%	231,010	3.2%
Hatchery carcass	222,248	0.9%	245,642	0.9%	409,725	0.7%	112,881	1.6%
Total with hatchery surplus utilization	24,398,902	100.0%	28,614,251	100.0%	58,461,917	100.0%	7,249,852	100.0%
Total without hatchery surplus utilization	23,382,619		27,434,912		56,138,923		6,905,961	
Species: Spring/Summer Chinook								
Alaska	1,247,437	11.2%	1,311,767	11.2%	2,623,533	7.8%	411,745	13.6%
British Columbia	1,764,542	15.9%	1,856,639	15.8%	3,713,277	11.0%	573,534	18.9%
Washington ocean	532,560	4.8%	560,304	4.8%	1,120,608	3.3%	173,517	5.7%
Washington Puget Sound	19,825	0.2%	20,993	0.2%	41,985	0.1%	5,370	0.2%
Oregon	220,303	2.0%	231,830	2.0%	463,660	1.4%	71,370	2.4%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,127,562	19.2%	2,234,885	19.1%	8,990,462	26.6%	721,616	23.8%
Tributary	0	0.0%	0	0.0%	1,506,898	4.5%	0	0.0%
Gillnet	1,747,970	15.8%	1,836,144	15.7%	4,497,649	13.3%	592,868	19.5%
Tribal	248,507	2.2%	269,032	2.3%	6,261,798	18.5%	538	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	2,992,786	27.0%	3,200,379	27.3%	4,359,440	12.9%	404,233	13.3%
Hatchery carcass	188,940	1.7%	197,393	1.7%	244,586	0.7%	79,518	2.6%
Total with hatchery surplus utilization	11,090,431	100.0%	11,719,364	100.0%	33,823,897	100.0%	3,034,310	100.0%
Total without hatchery surplus utilization	7,908,705		8,321,593		29,219,871		2,550,559	
Species: Fall Chinook								
Alaska	2,352,286	5.8%	2,838,088	5.7%	5,676,176	5.2%	1,420,898	6.0%
British Columbia	16,060,162	39.9%	19,328,072	38.5%	38,656,145	35.4%	10,176,525	43.0%
Washington ocean	7,298,685	18.1%	9,473,119	18.9%	22,542,414	20.7%	4,141,848	17.5%
Washington Puget Sound	224	0.0%	284	0.0%	629	0.0%	112	0.0%
Oregon	1,328,284	3.3%	1,718,309	3.4%	4,051,936	3.7%	742,102	3.1%
California	162,083	0.4%	211,709	0.4%	512,469	0.5%	94,719	0.4%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,612,493	6.5%	3,396,348	6.8%	8,117,941	7.4%	1,493,872	6.3%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	4,423,246	11.0%	5,688,803	11.3%	13,198,355	12.1%	2,403,171	10.2%
Tribal	4,815,713	12.0%	6,094,991	12.1%	13,495,301	12.4%	2,414,571	10.2%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	757,659	1.9%	977,090	1.9%	2,284,273	2.1%	417,071	1.8%
Hatchery carcass	441,114	1.1%	455,866	0.9%	543,743	0.5%	371,269	1.6%
Total with hatchery surplus utilization	40,251,950	100.0%	50,182,678	100.0%	109,079,381	100.0%	23,676,157	100.0%
Total without hatchery surplus utilization	39,053,176		48,749,723		106,251,365		22,887,817	

Table A-17 (continued)

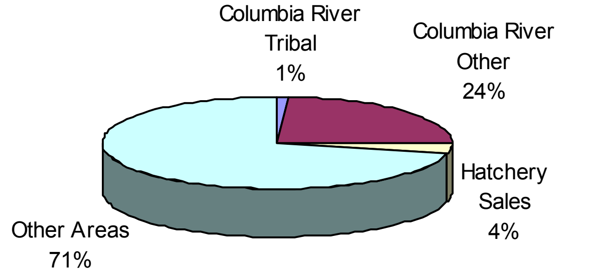
	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Summer/Winter Steelhead								
Alaska	3,203	0.0%	7,116	0.0%	14,233	0.0%	1,910	0.1%
British Columbia	39,650	0.6%	88,084	0.5%	176,168	0.6%	23,645	0.6%
Washington ocean	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Washington Puget Sound	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Oregon	3,203	0.0%	7,116	0.0%	14,233	0.0%	1,910	0.1%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,706,779	38.4%	6,292,245	37.0%	11,874,912	37.2%	1,177,319	32.1%
Tributary	3,268,905	46.4%	8,098,924	47.6%	14,069,114	44.1%	1,882,489	51.3%
Gillnet	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Tribal	408,976	5.8%	1,013,265	6.0%	2,640,304	8.3%	235,520	6.4%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	481,041	6.8%	1,256,747	7.4%	2,667,466	8.4%	251,351	6.8%
Hatchery carcass	136,420	1.9%	245,598	1.4%	444,151	1.4%	95,744	2.6%
Total with hatchery surplus utilization	7,048,177	100.0%	17,009,095	100.0%	31,900,579	100.0%	3,669,889	100.0%
Total without hatchery surplus utilization	6,430,716		15,506,750		28,788,962		3,322,794	
Species: Total								
Alaska	3,603,098	4.4%	4,157,171	3.9%	8,314,341	3.6%	1,834,611	4.9%
British Columbia	18,795,784	22.7%	22,355,263	20.8%	44,710,527	19.2%	11,078,433	29.4%
Washington ocean	15,763,754	19.0%	19,345,968	18.0%	42,737,479	18.3%	6,652,783	17.7%
Washington Puget Sound	51,156	0.1%	57,613	0.1%	116,942	0.1%	15,003	0.0%
Oregon	9,422,051	11.4%	11,187,216	10.4%	23,430,004	10.0%	3,152,962	8.4%
California	639,193	0.8%	775,990	0.7%	1,670,508	0.7%	227,192	0.6%
Columbia Basin inland								
Freshwater sport								
Mainstem	9,896,090	12.0%	14,786,818	13.8%	34,841,683	14.9%	4,137,906	11.0%
Tributary	3,268,905	3.9%	8,098,924	7.5%	15,576,012	6.7%	1,882,489	5.0%
Gillnet	9,584,247	11.6%	11,517,601	10.7%	25,866,341	11.1%	4,029,281	10.7%
Tribal	5,750,938	6.9%	7,730,413	7.2%	23,135,284	9.9%	2,656,472	7.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	5,025,522	6.1%	6,367,912	5.9%	11,224,449	4.8%	1,303,665	3.5%
Hatchery carcass	988,722	1.2%	1,144,498	1.1%	1,642,204	0.7%	659,412	1.8%
Total with hatchery surplus utilization	82,789,460	100.0%	107,525,388	100.0%	233,265,774	100.0%	37,630,209	100.0%
Total without hatchery surplus utilization	76,775,216		100,012,977		220,399,121		35,667,132	

Source: Study.

Figure A-16
Regional Economic Impacts (RED Benefits) in West Coast Geographic Areas Attributable to Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases of Production and Harvest Management Policies

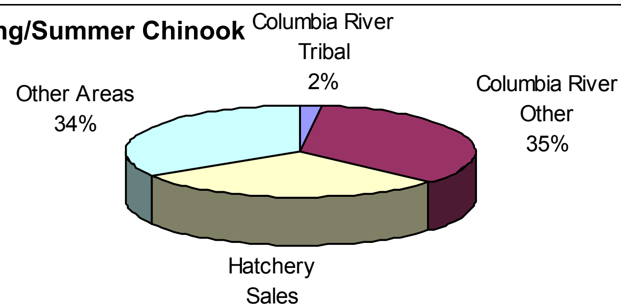
<table>
<tr><th></th><th>Total Smolts Released (millions)</th><th>Total Personal Income
I NMFS Cap
II 1980's Average
III "Doubling of Runs"
IV Early 1990's</th></tr>
<tr><td>

Coho



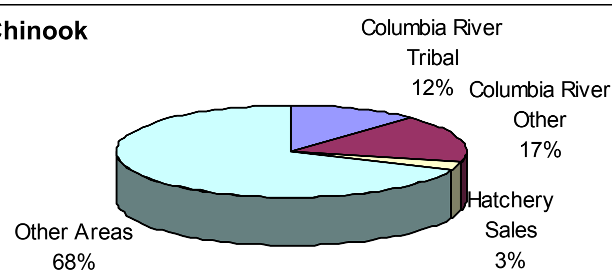
</td><td>37.18
37.18
37.18
30.91</td><td>I. $24.40
II. $28.61
III. $58.46
IV. $7.25</td></tr>
<tr><td>

Spring/Summer Chinook



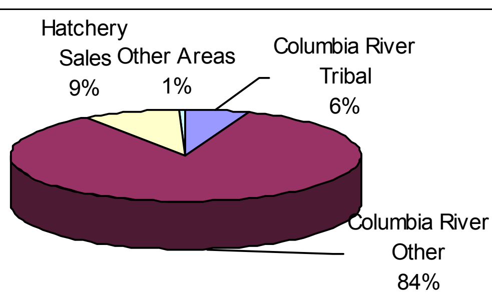
</td><td>39.13
39.13
39.13
36.78</td><td>I. $11.09
II. $11.72
III. $33.82
IV. $3.03</td></tr>
<tr><td>

Fall Chinook



</td><td>227.60
227.60
227.60
200.22</td><td>I. $40.25
II. $50.18
III. $109.08
IV. $23.68</td></tr>
<tr><td>

Steelhead



</td><td>28.63
28.63
28.63
25.15</td><td>I. $7.05
II. $17.01
III. $31.90
IV. $3.67</td></tr>
<tr><td>Total</td><td></td><td>I. $82.79
II. $107.53
III. $233.27
IV. $37.63</td></tr>
</table>

Note: 1. RED benefits are expressed as personal income in millions of 1998 dollars.
2. Columbia River other includes inriver commercial and recreational fisheries.

Source: Study.

volumes (about 60 percent of the total); the average adult harvested is also larger than the other species.

Most coho are produced in the lower Columbia and have historically been harvested off the coasts of Washington and Oregon. Lower Columbia gillnetters and recreational anglers have also harvested a portion of these runs. Spring/summer chinook from the upper Columbia and Snake River are caught only incidentally in ocean fisheries, while lower Columbia and Willamette River produced fish have historically contributed substantially to the Alaska/B.C. commercial fisheries, as well as the inland commercial and recreational fisheries. Fall chinook is the economic producer for the Pacific Northwest regional economy. Alaska and Canada harvesters receive about 30 percent of the total income from harvesting these fish produced in the Columbia Basin. Fall chinook is also the major producer of income for the tribal fisheries in the Columbia. Fall chinook production in-river makes up almost 50 percent of all personal income generated by these production cases. Steelhead are not harvested commercially in the Pacific Northwest, except by tribal treaty fisheries.

Recent policy goals, such as "doubling of the runs," may result in restored salmon runs contributing significant income to the region and the nation. The burden of these reductions would be felt from Alaska to California along the Pacific coast and as far as Idaho in the Columbia River Basin. The consequence of not recovering natural runs in the Columbia River Basin raises the possibility of eliminating much of the harvesting of salmon produced in the Columbia River Basin within its migration route.

3. Potential Net Economic Value (NED Benefits)

The potential net economic value (NED benefits) results may be viewed as the value of what may be lost to the nation if survival rates are not increased. The potential net economic value (NED benefits) of harvestable fish under the first three cases ranges from $55 million per year under the NMFS cap case to $160 million per year (Table A-18 and Figure A-17). The latter assumes that "doubling of the runs" may be achieved. The fourth case includes the survival rates that are being experienced in the 1990's. At these low survival rates, with present hatchery smolt releases, the net economic value (NED benefits) throughout the region would total $25 million per year.

C. Risk and Uncertainty in Modeling the Economic Values

1. Introduction

The economic values from the Columbia River Basin anadromous fish runs are determined using forecasted harvests throughout their migration routes. The actual harvestable fish depends on the productivity of the inland water system as well as the ocean system. Inland water system production factors can include harvesting methods, habitat alterations, hatchery production, hydrosystem operations, and ocean conditions. Strategies for recovery can address manmade factors, the more immediate remedies being harvesting methods, hydrosystem operations, and hatchery production. A short discussion of the variability in economic analysis

Table A-18
Net Economic Values (NED Benefits) of Columbia River Basin Produced Salmon/Steelhead by Geographic Areas For Four Cases of Production and Harvest Management Policies

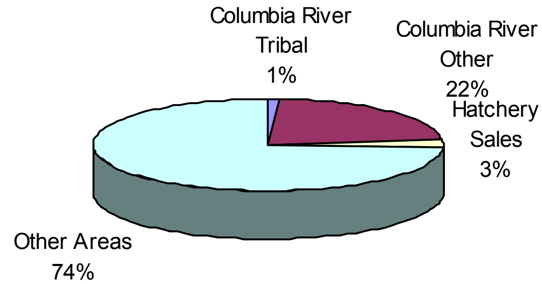
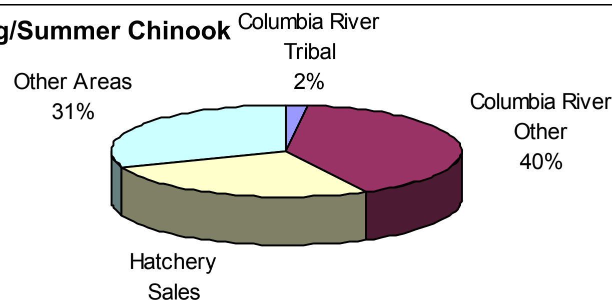
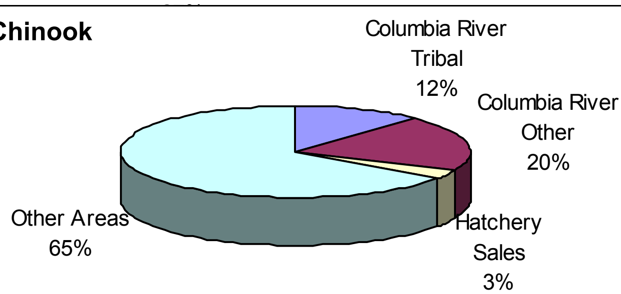
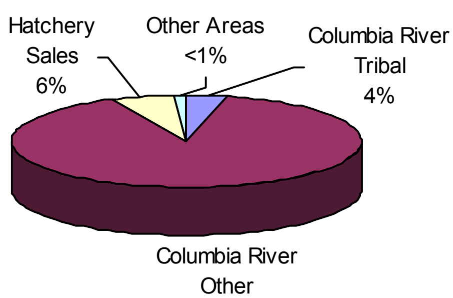
	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Coho								
Alaska	83	0.0%	96	0.0%	191	0.0%	27	0.0%
British Columbia	540,796	2.9%	628,473	2.9%	1,256,945	2.8%	176,966	3.2%
Washington ocean	6,721,240	36.0%	7,890,826	36.0%	16,162,563	36.1%	1,979,963	35.7%
Washington Puget Sound	24,311	0.1%	28,398	0.1%	58,090	0.1%	7,440	0.1%
Oregon	6,164,564	33.0%	7,230,071	33.0%	14,805,269	33.0%	1,830,011	33.0%
California	332,134	1.8%	392,980	1.8%	806,574	1.8%	91,904	1.7%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,099,420	11.2%	2,454,360	11.2%	5,021,598	11.2%	638,674	11.5%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	2,025,291	10.8%	2,369,238	10.8%	4,848,273	10.8%	613,125	11.0%
Tribal	164,812	0.9%	209,544	1.0%	437,859	1.0%	3,467	0.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	484,135	2.6%	569,289	2.6%	1,166,549	2.6%	140,850	2.5%
Hatchery carcass	136,683	0.7%	151,070	0.7%	251,981	0.6%	69,422	1.3%
Total with hatchery surplus utilization	18,693,469	100.0%	21,924,345	100.0%	44,815,892	100.0%	5,551,848	100.0%
Total without hatchery surplus utilization	18,072,651		21,203,986		43,397,362		5,341,576	
Species: Spring/Summer Chinook								
Alaska	614,193	9.3%	645,862	9.3%	1,291,725	6.0%	202,764	11.0%
British Columbia	912,298	13.8%	959,920	13.8%	1,919,839	8.9%	296,476	16.1%
Washington ocean	317,075	4.8%	333,680	4.8%	667,359	3.1%	102,611	5.6%
Washington Puget Sound	11,286	0.2%	11,942	0.2%	23,884	0.1%	3,132	0.2%
Oregon	157,763	2.4%	166,018	2.4%	332,036	1.5%	51,109	2.8%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	1,823,675	27.6%	1,915,669	27.5%	7,706,325	35.8%	618,546	33.5%
Tributary	0	0.0%	0	0.0%	1,588,019	7.4%	0	0.0%
Gillnet	885,598	13.4%	930,271	13.3%	2,278,706	10.6%	300,373	16.3%
Tribal	125,905	1.9%	136,303	2.0%	3,172,500	14.7%	273	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	1,637,137	24.8%	1,750,696	25.1%	2,384,735	11.1%	221,127	12.0%
Hatchery carcass	116,198	1.8%	121,396	1.7%	150,420	0.7%	48,904	2.7%
Total with hatchery surplus utilization	6,601,128	100.0%	6,971,756	100.0%	21,515,547	100.0%	1,845,313	100.0%
Total without hatchery surplus utilization	4,847,793		5,099,664		18,980,393		1,575,283	
Species: Fall Chinook								
Alaska	1,151,779	4.9%	1,389,651	4.7%	2,779,301	4.3%	695,708	5.0%
British Columbia	8,390,928	35.6%	10,097,472	34.2%	20,194,944	31.2%	5,325,036	38.6%
Washington ocean	4,855,956	20.6%	6,305,358	21.4%	15,021,931	23.2%	2,761,199	20.0%
Washington Puget Sound	161	0.0%	204	0.0%	451	0.0%	81	0.0%
Oregon	830,436	3.5%	1,074,277	3.6%	2,533,249	3.9%	463,958	3.4%
California	80,873	0.3%	105,632	0.4%	255,687	0.4%	47,257	0.3%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,239,342	9.5%	2,911,236	9.9%	6,958,429	10.8%	1,280,497	9.3%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	2,524,963	10.7%	3,247,393	11.0%	7,534,141	11.6%	1,371,825	9.9%
Tribal	2,748,999	11.7%	3,479,261	11.8%	7,703,649	11.9%	1,378,332	10.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	464,783	2.0%	599,391	2.0%	1,401,277	2.2%	255,850	1.9%
Hatchery carcass	271,285	1.2%	280,357	1.0%	334,402	0.5%	228,331	1.7%
Total with hatchery surplus utilization	23,559,504	100.0%	29,490,233	100.0%	64,717,461	100.0%	13,808,075	100.0%
Total without hatchery surplus utilization	22,823,436		28,610,485		62,981,782		13,323,894	

Table A-18 (continued)

	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Summer/Winter Steelhead								
Alaska	2,822	0.0%	6,268	0.0%	12,537	0.0%	1,683	0.0%
British Columbia	20,359	0.3%	45,228	0.3%	90,456	0.3%	12,141	0.4%
Washington ocean	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Washington Puget Sound	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Oregon	2,822	0.0%	6,268	0.0%	12,537	0.0%	1,683	0.0%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,384,221	36.8%	5,542,419	35.4%	10,459,818	36.2%	1,037,022	30.6%
Tributary	3,444,881	53.2%	8,534,916	54.5%	14,826,501	51.3%	1,983,830	58.5%
Gillnet	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Tribal	241,899	3.7%	599,320	3.8%	1,561,672	5.4%	139,304	4.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	295,531	4.6%	772,090	4.9%	1,638,774	5.7%	154,419	4.6%
Hatchery carcass	83,898	1.3%	151,043	1.0%	273,153	0.9%	58,882	1.7%
Total with hatchery surplus utilization	6,476,431	100.0%	15,657,552	100.0%	28,875,447	100.0%	3,388,964	100.0%
Total without hatchery surplus utilization	6,097,002		14,734,419		26,963,520		3,175,662	
Species: Total								
Alaska	1,768,876	3.2%	2,041,877	2.8%	4,083,754	2.6%	900,183	3.7%
British Columbia	9,864,380	17.8%	11,731,092	15.8%	23,462,185	14.7%	5,810,619	23.6%
Washington ocean	11,894,271	21.5%	14,529,864	19.6%	31,851,853	19.9%	4,843,772	19.7%
Washington Puget Sound	35,758	0.1%	40,544	0.1%	82,425	0.1%	10,653	0.0%
Oregon	7,155,585	12.9%	8,476,635	11.4%	17,683,090	11.1%	2,346,761	9.5%
California	413,007	0.7%	498,612	0.7%	1,062,261	0.7%	139,161	0.6%
Columbia Basin inland								
Freshwater sport								
Mainstem	8,546,659	15.4%	12,823,684	17.3%	30,146,169	18.9%	3,574,738	14.5%
Tributary	3,444,881	6.2%	8,534,916	11.5%	16,414,520	10.3%	1,983,830	8.1%
Gillnet	5,435,852	9.8%	6,546,902	8.8%	14,661,119	9.2%	2,285,322	9.3%
Tribal	3,281,614	5.9%	4,424,429	6.0%	12,875,680	8.1%	1,521,376	6.2%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	2,881,585	5.2%	3,691,466	5.0%	6,591,335	4.1%	772,246	3.1%
Hatchery carcass	608,064	1.1%	703,866	1.0%	1,009,956	0.6%	405,538	1.6%
Total with hatchery surplus utilization	55,330,532	100.0%	74,043,887	100.0%	159,924,347	100.0%	24,594,200	100.0%
Total without hatchery surplus utilization	51,840,882		69,648,554		152,323,057		23,416,415	

Source: Study.

Figure A-17
Net Economic Value (NED Benefits) in West Coast Geographic Areas Attributable to Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases of Production and Harvest Management Policies

	Total Smolts Released (millions)	Net Economic Value I NMFS Cap II 1980's Average III "Doubling of Runs" IV Early 1990's
Coho 	37.18 37.18 37.18 30.91	I. $18.69 II. $21.92 III. $44.82 IV. $5.55
Spring/Summer Chinook 	39.13 39.13 39.13 36.78	I. $6.60 II. $6.97 III. $21.52 IV. $1.85
Fall Chinook 	227.60 227.60 227.60 200.22	I. $23.56 II. $29.49 III. $64.72 IV. $13.81
Steelhead 	28.63 28.63 28.63 25.15	I. $6.48 II. $15.66 III. $28.88 IV. $3.39
Total		I. $55.33 II. $74.04 III. $159.92 IV. $24.59

Note: 1. NED benefits expressed in millions of 1998 dollars.
2. Columbia River other includes inriver commercial and recreational fisheries.

Source: Study.

results due to these remedy factors follows. The factors are explained in terms of markets, smolt-to-adult survival rates, hatchery and harvest management. The magnitude of the effect of the assumptions are shown in the case of the four alternative management strategies discussed in previous sections.

2. Markets

a. Commercial Fishing

For centuries, salmon have sustained the people of the Pacific Northwest. They were an important food source, cultural symbol, and means of trade for American Indians. As western development took place, salmon runs provided jobs and income to harvesters, cannery workers, and related industries throughout the region. As water based economic development took place in the Pacific Northwest, natural based production was supplemented by artificial propagation.

Artificial propagation was at first limited to egg incubation. For some salmon species, in order to increase egg-to-adult survival rates, the propagation process included fry and later smolt releases. Smolt production may cost $0.50 to $1.00 per smolt. The high cost of smolt production combined with low overall survival rates of free ranging salmon (salmon ranching) has led to growing salmon in cages (salmon farming) where smolts will survive at about 80 to 90 percent. The farming process is now producing about 50 percent of the world salmon market. The price of salmon for the fresh and frozen market is now generally set by farmed salmon. These prices are dependent on markets but also on the main ingredient in farming salmon, the feed costs. There are a range of substitutes available; therefore, no dramatic changes are expected in the price level of commercial salmon produced from the Columbia Basin.

More variation may be expected in utilization of a substantial portion of the anadromous fish that return as hatchery "surplus" and are not harvested. For wild fish, this is presently not a problem. However, in some cases, returns to hatcheries over and above what is needed for propagation are a resource that could provide additional benefits to the Pacific Northwest region.

According to lower Columbia River processors, about 50 percent of the fall returning fish and 100 percent of the summer returning fish could be utilized for developed markets (personal communication with processor facility operators, April 1999). Development of markets would include the traditional fresh and frozen markets, as well as value added products, such as ready to purchase fillet steaks and ready to eat portions. Other specialty products may also include canned and smoked products. Egg production for the Japanese market may also have a significant potential (Radtke and Davis, January 1996).

Without any hatchery utilization for food fish, the benefits under the four policy cases analyzed for the entire Columbia River Basin range from $35.7 to $220.4 million in regional economic impacts and $23.4 to $152.3 million in net economic value (Table A-19). These benefits

Table A-19
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different Hatchery Utilization Assumptions

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Without Hatchery Utilization				
Regional economic impacts	76.8	100.0	220.4	35.7
Net economic value	51.8	69.6	152.3	23.4
Difference analysis results impacts	(6.0)	(7.5)	(12.9)	(2.0)
Difference analysis results value	(3.5)	(4.4)	(7.6)	(1.2)
With 100% Hatchery Utilization for Steelhead and Spring Chinook and 50% for Fall Chinook and Coho				
Regional economic impacts	86.1	111.7	239.7	38.2
Net economic value	57.1	76.4	163.6	24.9
Difference analysis results impacts	3.3	4.1	6.5	0.6
Difference analysis results value	1.8	2.3	3.7	0.3

Note: Regional economic impacts and net economic value in millions of 1999 dollars.
Source: Study.

would be increased ($38.2 to $239.7 million in personal income; $24.9 to $163.6 million in net value) by developing products and markets to utilize 50 percent of the fall fish and 100 percent of the spring/summer fish.

b. Recreational Angling

Since World War II, there has been a steady increase in outdoor activity in the West. Between 1945 and the early 1970's, recreation activity on public lands grew by more than 10 percent per year, driven by rapid population growth, increased affluence, improvements in cars and interstate highways, decreased real gasoline prices, increased air travel, and the decline of the average work week to 40 hours and five days (Walsh 1986).

Population growth and the proportion of that population having a degree of affluence are the most significant factors contributing to the increases in recreation activity (English et al. 1993). The significant population increases expected for the West indicated major increases in recreation activity related to public resources (Haynes and Horne 1996).

In general, the assumption of one fish per day is used in this evaluation of the benefits of recreational angling in ocean fishing. Past studies of ocean salmon fishing suggest the success of one day per fish is a reasonable representation of historical trends. Since salmon/steelhead fishing has been curtailed inland during the last few years, no clear studies of motivation factors, such as fishing success rates needed to attract anglers, have been completed. The ODFW utilizes a day per fish success rate for ocean fishing and up to two days per fish success rates for inland fishing (Carter, March 1999a). The State of Idaho conducts annual surveys of anglers (Bowler 1999). For tributaries above the Columbia River/Snake River confluence, a two days per fish success rate for wild, non-retained, and hatchery retained fish has been experienced. For retained steelhead only, the days per fish ratio has been 5.88. A study by Reading (1999) suggests that in Idaho the average success rate for anadromous fish is one fish for about 6.5 days of fishing. Future demand for outdoor recreation suggests that a success rate of as low as 10 days per fish may be enough to attract anglers to fish for anadromous fish in some inland waters.

Lowering the success rates from the base case of one day per fish in the ocean and up to two days per fish in the river to three or 10 days increases the benefits substantially (Table A-20) for the four policy cases analyzed for the Columbia River Basin. An increase to three days per fish for all recreational fisheries may increase the personal income generated to $271.3 million ($194.2 million in net economic value). An increase to 10 days per fish increases these potential numbers to $477.8 million and $382.9 million. This is about two times the benefit from all harvests that is presently generated or what may be potentially generated under the four policy cases.

3. Smolt-to-Adult Survival Rates

Smolt production and resulting adult harvests are the base for evaluating fishery benefits. The four policy cases evaluated for the entire Columbia River Basin included best estimates of survival rates experienced for a 30 year average (Case I), 1980's average (Case II), and the early 1990's (Case IV). Case III uses a hypothetical survival rate necessary to double harvests when hatchery production is at the NMFS cap. The 1980's actual runs survival rates could be considered the base (Table A-21). The increased survival rates needed for the "doubling of the runs" objective may come from increased survival rates of hatchery and wild fish or from increasing runs of wild fish. The survival rates of the 1990's have generally been about one half to one third of what the runs were in the 1980's and are only about 15 to 30 percent of what they need to be to achieve the doubling of the runs objective.

There are indications that ocean conditions during the last decade have been poor, as far as anadromous fish survival. Ocean conditions are, however, only one of several natural and human caused factors that affect total survival. In the period 1996-1998, up to 195 million hatchery smolts were released in the Columbia Basin system. In addition, another 136 million wild smolts were produced. Therefore, about 331 million smolts per year entered the Columbia Basin. Out of this total, about 100 million smolts entered the Columbia estuary (Pollard 1999). This is a 70 percent loss of smolts in the upriver system. In the lower estuary, avian predation accounts for significant mortality. "If the level of avian predation in 1999 is again in the 12 to 35 million range . . ." (Pollard 1999), then up to 80 percent of smolts produced in the Columbia system would have died before entering the ocean system.

In order to produce the harvestable numbers of the 1980's, an overall ocean survival rate of four percent would be required. In order to reach the "doubling of runs" objective, a 7.5

Table A-20
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different Angler Success Rate Assumptions

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results, Success Rate 1				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Increase Recreational Inland Success Rate to 3				
Regional economic impacts	94.4	125.0	271.3	42.5
Net economic value	65.6	89.9	194.2	29.0
Difference analysis results impacts	11.6	17.4	38.1	4.9
Difference analysis results value	10.3	15.8	34.3	4.4
Increase Recreational Inland Success Rate to 10				
Regional economic impacts	152.0	219.0	477.8	67.9
Net economic value	117.5	176.6	382.9	52.2
Difference analysis results impacts	69.3	111.5	244.5	30.3
Difference analysis results value	62.2	102.6	222.9	27.6

Notes: 1. Regional economic impacts and net economic value in millions of 1999 dollars.
2. Success rate expressed as days per fish.
Source: Study.

percent ocean survival rate would be required. There is speculation, based on limited research, that wild fish survive at higher rates. One study suggests that wild fall chinook in the lower Columbia River survive "at an average rate that may be as high as 12 times greater than the average of Columbia River hatchery stocks" (McIsaac 1990). A recovery plan for wild fish, that also will increase downstream passage survival of hatchery smolt production, would have to result in total harvestable numbers evaluated under the "doubling of the runs" scenario.

The PATH results did not generate SAR's as modeled outputs. It was possible to generate an indicator SAR using the five year increment outputs of harvests and spawners. These SAR's are referenced as indicator rates because insufficient information about age-structures, interdam mortality, and other factors was available to determine a more precise rate In general, for PATH modeled results there must be a seven fold increase in the indicator SAR's for spring/summer chinook and a two to three fold increase for fall chinook between the initial Project years and at Project Year 50, in order for spawners to be at the forecasted level. Obviously, economic values will be significantly affected by a lesser improvement.

Table A-21
Smolt-to-Adult Survival Rate Assumptions Used For Four Cases of
Production and Harvest Management Policy in the Columbia River Basin

	Snake River	Upper Columbia	Middle Columbia	Lower Columbia	Willamette	Weighted Average
Coho						
I. NMFS Cap (1970's-1990's Actual)	NA	1.20%	1.20%	2.50%	1.20%	2.33%
II. 80's Actual Runs	NA	1.49%	1.49%	2.90%	1.49%	2.72%
III. Run Doubling Objective	NA	2.98%	2.98%	5.80%	2.98%	5.43%
IV. Early 90's Runs	NA	0.15%	0.15%	1.00%	0.40%	0.90%
Spring/Summer Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.37%	0.37%	0.37%	0.97%	0.97%	0.65%
II. 80's Actual Runs	0.39%	0.39%	0.39%	1.01%	1.02%	0.69%
III. Run Doubling Objective	0.79%	0.79%	0.79%	2.03%	2.04%	1.37%
IV. Early 90's Runs	0.10%	0.10%	0.10%	0.35%	0.35%	0.22%
Fall Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.60%	0.60%	0.60%	0.32%	NA	0.41%
II. 80's Actual Runs	0.73%	0.73%	0.73%	0.38%	NA	0.49%
III. Run Doubling Objective	1.45%	1.45%	1.45%	0.77%	NA	0.99%
IV. Early 90's Runs	0.40%	0.40%	0.40%	0.25%	NA	0.30%
Steelhead						
I. NMFS Cap (1970's-1990's Actual)	0.70%	0.70%	0.70%	0.40%	0.40%	0.62%
II. 80's Actual Runs	1.56%	1.56%	1.56%	0.89%	0.89%	1.38%
III. Run Doubling Objective	3.11%	3.11%	3.11%	1.78%	1.78%	2.76%
IV. Early 90's Runs	0.50%	0.50%	0.50%	0.20%	0.20%	0.42%

Notes: 1. Rates expressed as representative percents of hatchery reared smolts released divided by adults contributing to fisheries plus adults returning to hatcheries. Survival rates are best estimates based on information provided by the "Annual Coded Wire Program - Missing Production Groups" annual reports (Fuss et al. 1994 and Garrison et al. 1995).
2. Survival rate assumptions for the "Run Doubling Objective" case are the survival rates that would be required to meet the objectives.

Source: Study.

4. Harvest Management

a. Hatchery Production

It is assumed that hatchery management is based on past mitigation agreements and that hatchery release goals are defined by the present NMFS cap on hatchery releases. The role of supplementation hatcheries is not specifically included in the evaluation.

If natural resource based recreation increases as discussed earlier, a challenge to management may be to convert hatchery surplus to inland recreational angling. The allocation shift may increase regional annual personal income as much as $541.4 million ($499.9 million in net economic value) for the entire Columbia River Basin production (Table A-22). This, of course, assumes that hatchery surplus fish may be caught without affecting other objectives, such as endangered species recovery.

Under the NMFS cap, hatchery releases are to be below 197 million smolts per year. "The total hatchery production in 1999 is projected to be in the range of 140 to 150 million smolts, down from the 185 to 195 million range of 1996 to 1998 releases. These reductions are due to ESA concerns, fiscal cutbacks and the failure of some hatchery programs to receive sufficient spawning escapement in the last two years." (Pollard 1999). This is in effect a 25 percent reduction in hatchery releases. Unless wild fish production increases, a reduction of about 25 percent in economic benefits could be anticipated if this reduction in hatchery releases continues. The other expectation may be that decreased hatchery releases increases wild fish survival and that the reduction in hatchery releases increases the number of returning wild spawners, which in turn increases overall production.

The John Day Dam sponsored hatchery release (1999 goals) was 11,500,000 smolts. Under periods of good ocean conditions this should have made available for harvest about 144,000 adult fish (74,000 potential adult returns; 1.25 percent overall survival rate)[1]. Under poor ocean conditions, such as the 1990's, the overall survival rates for middle Columbia released hatchery fall chinook was .4 percent. At this rate 47,600 adult returns would be expected.

The relationship between increased wild spawner returns and hatchery management was not analyzed in this report. Hatchery production and smolt releases are subject to many factors. Original mitigation agreements are one of these factors. Other agreements between nations, or with historical user groups, may change the total amount of smolt releases for any period. The John Day Pool analysis spawning potential was made without consideration of changes in hatchery releases resulting from John Day Pool water management actions.

b. User Group Allocations

There are a host of salmon treaties and agreements that affect salmon of the Columbia River system. This report assumes that international and treaty agreements will not change. Under the four scenarios, the allocation to any of the historical harvesters changes only if spawning requirements and treaty obligations are met. There are no treaties on allocation of salmon harvests between commercial and recreational harvesters, only user group allocation agreements. Any future reallocation of such harvests may result in a shift of economic benefits between users or regions, and may also change the total benefits generated.

The situation for shifting production between user groups is complicated because of the overriding influence of summer steelhead contributions to fisheries. There is very little non-treaty commercial use for steelhead. Spring/summer chinook do not have a significant ocean commercial fishery and have not had a viable river gillnet fishery since the late 1980's.

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1. Willis (1999).

Table A-22
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different Harvest Management Assumptions

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Convert Hatchery Surplus to Inland Recreation at Base Case Success Rate				
Regional economic impacts	95.4	127.2	271.7	41.9
Net economic value	68.6	94.7	199.8	28.9
Difference analysis results impacts	12.6	19.7	38.5	4.2
Difference analysis results value	13.3	20.7	39.9	4.3
Convert Hatchery Surplus to Inland Recreation at Success Rate 3				
Regional economic impacts	122.9	166.2	352.5	51.9
Net economic value	93.1	130.0	272.7	37.9
Difference analysis results impacts	40.2	58.7	119.3	14.2
Difference analysis results value	37.7	56.0	112.8	13.3
Convert Hatchery Surplus to Inland Recreation at Success Rate 10				
Regional economic impacts	259.1	371.5	774.6	102.2
Net economic value	215.8	319.0	659.8	83.7
Difference analysis results impacts	176.3	263.9	541.4	64.6
Difference analysis results value	160.5	245.0	499.9	59.1

Notes: 1. Regional economic impacts and net economic value in millions of 1999 dollars.
2. Success rate expressed as days per fish.

Source: Study.

Therefore, converting all species from recreational to commercial fisheries will have little effect for increasing economic values from commercial fisheries.

A total allocation from recreational harvest to commercial may decrease personal income generated in the region between $8.1 million and $64.7 million (net economic value from $9.2 to $71.6 million) for the entire Columbia River Basin production (Table A-23). A shift from commercial to recreational use (assuming a one fish per day success rate) may increase annual regional economic impacts by $7.3 to $55.1 million (net economic value from $13.1 to $80.3 million) for the entire Columbia River Basin production.

Table A-23
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different User Group Allocations

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Convert Recreational to Commercial				
Regional economic impacts	61.7	75.2	168.6	29.5
Net economic value	32.3	39.5	88.3	15.3
Difference analysis results impacts	(21.1)	(32.3)	(64.7)	(8.1)
Difference analysis results value	(23.0)	(34.6)	(71.6)	(9.2)
Convert Commercial to Recreational				
Regional economic impacts	104.2	133.2	288.4	44.9
Net economic value	86.7	111.6	240.2	37.6
Difference analysis results impacts	21.4	25.6	55.1	7.3
Difference analysis results value	31.3	37.6	80.3	13.1

Note: Regional economic impacts and net economic value in millions of 1999 dollars.
Source: Study.

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ATTACHMENT B

ECONOMIC EVALUATION METHODS

ATTACHMENT B. METHODS USED TO CALCULATE REGIONAL ECONOMIC IMPACTS AND NET ECONOMIC VALUE

A. Background

The study's overall goal is to evaluate the economic contributions and values from harvesting Columbia Basin anadromous fish stocks that are assisted by removal or change in the operation of the John Day Dam. This study specifically analyzes the economic effects of changes in upriver wild stocks related to changes in salmon migration resulting from water flows in the John Day Pool. The assumption is made that the John Day Water Management alternatives would be considered only as part of the Lower Snake four dam removal alternatives. The economic contribution of the wild salmon fish stocks as well as the total Columbia River Basin anadromous production is measured in terms of direct earnings and indirect/induced personal income. The economic contribution expenditure budgets serve as a base to develop estimates of benefit (net economic value) for anadromous fish harvesting and primary processing.

The economy of the Pacific Northwest (Alaska and British Columbia are included in this definition, as are other of the Pacific Northwest states) is highly dependent on its natural resources. The natural resources provide raw materials for manufacturing processes, such as the production of lumber and plywood, and commercial fish processing among other things. The natural resources also attract recreation seekers who are both residents and from all over the world. In addition to the users of the natural resources, people who never touch or view the resources also place a value on them. They are people who may only wish to use the resource themselves or hope their relatives will be able to experience it. Methods to measure these economic values and dependence is complex. This report explains how only one aspect of the natural resources - fishing - is important to people and how it contributes to the economy. It also explains how management and other policy issues involving fisheries are related within the context of the economic measurements.

The two basic economic terms used in this report are "economic valuation" and "economic impact." <u>Net economic valuation</u> attempts to measure the benefits received by those that fish and the value people place on fishing. There also may be economic values to "nonusers," i.e. preservation or existence values to people who don't actually visit the Pacific Northwest. <u>Regional economic impact</u> considers how many people participate in fishing and how much they spend while fishing. The separate estimates are necessary to determine both the benefits and economic contributions to the economy. This report does not address the costs of providing the resources or services. Neither are the economic impacts included of the provision of fish resources. Generally, only the end products are valued, such as a recreational fishing day or a commercial fish harvested.

The following sections describe the different types of market and nonmarket economic values and regional economic impacts, and discuss applications and methodological concerns of economic information when applied to allocation issues.

B. Measuring Economic Values

1. Economic Valuation

Economic value is only one of many ways to describe the "worth" of some resource or service. The fishery resource provides an excellent example of this. Native salmon have many different types of value. A biologist may say that the values of the native fish are their genetic contribution to the survival of the species. An angler may say that the value of the native fish is in their challenge and fight, and the sense of accomplishment at having landed one. A nutritionist may find no difference in the value of native and hatchery fish, both providing the same calories, protein, etc. All of these people would be describing some aspect of the value of native fish, but none would be describing the economic value.

Economic value is very precisely defined as the relative value of a good or service, or what someone would be willing to give up (pay) in exchange for that good or service. This definition describes an anthropocentric view of value, that is, value to people. Therefore, for a fishery resource to have economic value, people must be willing to give up other valuable resources (which can be represented by money) in order to have the fishery resource. Clearly this makes economic value a function of peoples, preferences and their ability to pay (income).

When measuring economic value, it is not necessary to know why people value a resource (e.g. for nutritional reasons, for biological reasons, for recreation reasons), but rather how much they value it relative to other things. This makes it clear that economics is the appropriate tool when the objective is to allocate scarce resources. (A scarce resource is defined as a resource that people desire and need and of which there is a limited amount. A resource such as air may not fit this definition unless clean air becomes polluted.) For example, if something of value must be given up to save native fish populations, society needs to know whether the native fish are worth more than what must be given up. Information about the biological, nutritional, or recreational value of fish will certainly affect people's willingness to pay for the resource, but the economist does not need to know the motives behind people's willingness to pay in order to make socially efficient resource allocations. The calculation for social efficiency requires information on the total value of resources, that value being the result of many different motives. While recognizing that total value is the goal, there are methodological issues related to the measurement of economic value that have led to a distinction between different types of economic value.

a. Use Value

People may value a particular resource such as the fishery because they either use the resource currently, or they intend to use it at some time in the future. Current and future use value can be either direct or indirect. An example of direct use value would be the willingness of anglers to pay for access to the salmon in the Pacific fisheries. This may be actual price paid, which may be market price or any price that may not signal a "market clearing" price; an angler may be willing to pay more than he is being charged on the market. An example of indirect use value would be the willingness of a reader to pay for a magazine account of a fishing trip to the

Pacific Northwest. In both cases, someone had to actually use the site or resource in order for something of value to be produced.

Since the anadromous fish of the Columbia River Basin contribute to the overall ocean stocks, some of the use value of these fish is actually realized in the ocean fishery. In a sense, there is a derived demand for the habitat of Pacific Northwest rivers since they are an input into the ocean fishery "product."

The willingness to pay for future use of the resource is called option price. This price represents the expected value of the future trip (expected consumer surplus), plus (or minus) any "option value." The option value represents any additional (or less) willingness to pay (above expected consumer surplus) for the option of future use, when future use is uncertain. Some have described option value as a kind of insurance premium, to guarantee that the resource will be available when, and if, future use is desired.

b. Non-Use Value (Intrinsic Value)

There are some people who are willing to pay for a resource, even though they never intend to use it. This type of Non-use value is called existence value, because people are willing to pay to ensure that a resource exists, knowing that they will never actually use the resource. The motive for existence value may be that people want to ensure that a resource exists for future generations to enjoy. Some economists have separated this type of existence value into a separate category called bequest value, but it is clearly a subset of existence value.

c. Which Value to Measure?

It is likely that the fishery resource of the Pacific Northwest provides all of the above types of values to society. The decision about which ones to focus on for measurement is a function of the resource allocation question being asked. For example, if a particular fishery resource is not threatened with extinction, there is no need to measure the existence value of that resource. Since society would not be deciding whether to allocate scarce resources to save the fishery, the existence value is not relevant. If the policy decision under consideration is whether to invest resources to increase the fish populations, then the values which are measured must correspond to only the increase in fish numbers. In other words, total use value would not be the appropriate value to compare with the value of the resources necessary to increase the population by some incremental amount. Given the different types of policy decisions which might be relevant, as well as the fact that the existence of some Pacific Northwest fish populations may be in question, measurement of total and marginal values are likely to be useful to decision makers.

2. Regional Economic Impacts

The economic value of the fishery resource has been defined as people's willingness to give up resources of value (money) to have the fishery resource. This is commonly called net economic value or NEV (net economic value above costs) or NED's (National Economic Development accounts). A common mistake that is often made is to include the costs associated with using the fishery resource (e.g. travel costs, lodging costs, equipment) as part of the economic value of the resource. These associated costs, or expenditures, are instead the source of local or regional economic impacts associated with use of the fishery. These are commonly called the RED's (Regional Economic Development accounts).

Since economic values are used to allocate scarce resources, the economic value must represent the value of the fishery resource itself, and not the value of the related travel and equipment items. For example, suppose the fishery was threatened by a hydropower development and policy makers wanted to know whether the anglers could "buy out" the hydropower interests, All of the money spent on travel and equipment is no longer available to be used to buy out the competing hydropower interests. However, the money that is left over, after all the costs of angling have been paid, is the net willingness to pay (consumer surplus) for the fishery resource (or site) itself. and could be used to buy out the hydropower interests.

Another way to view the difference between economic value and economic impacts is to consider economic value as the net loss to society if the resource was no longer available. Suppose that a specific river fishery was no longer available to anglers, and they had to either fish somewhere else or engage in some other activity. The money spent on travel and equipment would not be lost to society - in fact it could be spent on travel and equipment or some other commodities in some other location. But the value anglers received from fishing that specific river would be lost. It must be assumed that one river's fishing was preferred over (had greater value than) the other rivers or activities, or the anglers wouldn't have chosen the one site in the first place. Their net willingness to pay for the chosen fishery would be a loss to society. Their expenditures or associated impacts on income or jobs would be a loss to the economy of the preferred river, but would be a gain to some other local economy. Economic impacts, therefore, describe the local or regional effects on jobs and income associated with any specific area chosen as the point of interest.

The above example should make it clear why local economies are often more concerned about economic impacts than economic values, especially when the economic values are in the form of consumer surplus. If anglers are willing to pay some amount of money over and above their costs, but don't actually have to pay, the consumers get to take that surplus or value home with them in their pockets. It is not immediately obvious to local businesses that the consumer surplus generated from any specific fishery has any impact on the local economy. On the other hand, money spent on lodging, food, supplies, guides, etc., has a direct impact on local businesses.

It is clear that net economic value and regional economic impacts are two distinct measures, and each is useful for different purposes. Net economic values are important if the goal is to allocate society's resources efficiently. Regional economic impacts are important in assessing the distributional impacts of the different allocation possibilities. It may often be the case that society will want to invest in a less valuable resource because the local area or economy that holds that resource is in need of economic development. Nevertheless, having the information on economic value will tell society how much they are giving up in order to achieve the redistribution of economic activity or development.

a. Input/Output Models

Economic input/output (I/O) models are used to estimate the impact of resource changes or to calculate the contributions of an industry to a regional economy. The basic premise of the I/O framework is that each industry sells its output to other industries and final consumers and in turn purchases goods and services from other industries and primary factors of production. Therefore, the economic performance of each industry can be determined by changes in both final demand and the specific inter-industry relationships.

I/O models can be constructed using surveys of a regional economy. The disadvantages of the survey model approach are its complexity and high cost. Construction of a survey data I/O model involves obtaining data on the sectorial distribution of local purchases and sales to final demand of every sector of the economy, and on the imports purchased and exports sold by each sector.

Another approach uses secondary data to construct estimates of local economic activity. The models developed for this project utilize one of the best known secondary I/O models available. The U.S. Forest Service has developed a computer system called IMPLAN which can be used to construct county or multi-county I/O models for any region in the U.S. The regional I/O models used by the Forest Service are derived from technical coefficients of a national I/O model and localized estimates of total gross outputs by sectors. IMPLAN adjusts the national level data to fit the economic composition and estimated trade balance of a chosen region. Areas that are any combination of single counties can be constructed using IMPLAN. The IMPLAN model is now being offered for general use by the Minnesota IMPLAN Group (Olson et al. 1993). Estimates of economic impacts and economic value of composite stocks harvested throughout the Pacific Northwest (including Canada and Alaska) are determined by the information made available on contributions of Columbia River stocks to fisheries. These composites are determined by the survival rates (from egg to adult) and the method and geographical location of harvests. The Fishery Economic Assessment Model (FEAM)[1], based on 1994 technical coefficients, is used to estimate economic impacts of salmon harvests.[2] The price and cost information in the FEAM is also used to calculate economic value of commercially harvested salmon. The FEAM model process is outlined in Figure B-1.

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1. Fishery Economic Assessment Model (FEAM) was developed for the West Coast Fisheries Development Foundation by Hans Radtke and William Jensen in 1986. Current models are available from Radtke or Jensen. The FEAM model uses IMPLAN generated coefficients to estimate specific expenditure to personal income impact relationships.
2. The available IMPLAN models are generally three to four years behind calendar years. This is due to data availability and the time it takes to prepare the models. Unless very dramatic changes take place in a regional economy, the sector coefficients will not change dramatically from year to year.

Figure B-1
The Fisheries Economic Assessment Model (FEAM) Process

- Based on IMPLAN
- Construct I/O coefficients for fishing related expenditures
- Species data
- Harvest data
- Primary processing data
- Economic impacts
  - Personal income
  - Full time job equivalents
- Geographic areas
  - Alaska
  - Canada
  - Washington
  - Oregon
  - California

Source: Study.

i. Imports and Exports

One way of measuring the contribution of a particular economic activity is to look at the amount of goods and services it sells and buys outside the local economy. A local economy has exports and imports similar to state or national exports and imports. Timber harvested and processed in Forks and shipped to Los Angeles is an export that benefits the local economy. The wind surfer from Seattle brings money to the Hood River area economy. Recreational activities are called exports when they bring in "outside" money. Exports from the local economy stimulate local economic activity.

However, the money brought into a local economy does not all stay in the local economy. This is particularly true for the smaller regional economies which are not economically self-sufficient. Many of the goods and services consumed in the local economy must be brought in from the outside. They are the imports to the local economy. The money that flows out of the local economy to pay for these imports is referred to as leakage.

In larger, more industrial diverse economies, there are fewer "leakages" of economic activity due to purchases from outside the region, and as a result, the multiplier effects are larger. In smaller, less diverse economies where more goods and services are purchased outside the region, regional impacts are smaller. For this reason, state impacts will almost always be larger than impacts for regions within the state.

The amount that a commercial fisherman spends to prepare a consumer-ready product for market, or a recreational fisherman spends to take part in a fishery, has an important impact on the local and regional economy. In addition, purchases made by the harvester, processor, or tourist-related businesses will cause suppliers to purchase additional inputs in the form of labor, more inventory, and other items. As workers and entrepreneurs receive wages, salaries, and profits from these activities, they spend money in the local area for a variety of goods and services. The total effect on the local economy depends upon the amount of the original dollar expenditures and the amount which is spent for subsequent purchases within the local economy. This effect is closely tied to the total expenditures, types of expenditures, and structure of the economy. So as not to confuse the size of economies between different areas, when comparisons are made between geographic areas, it makes more sense to use similar coefficients, such as state coefficients. (In comparisons between areas such as Alaska, Canada, Washington, or Oregon the state coefficients are probably the most appropriate to use. This is so that the size of the coefficients do not become the critical point in any policy comparisons.) The area of contribution chosen should therefore depend on the purpose of the comparisons.

ii. Basic Sectors

Since imports take money out of the economy, it is important for the smaller economies to have some exporting sectors. In the I/O jargon, these are called "basic sectors." The dollars brought in by basic or exporting sectors begin the multiplier process. The basic sectors stimulate a local economy by originating the multiplier effect. When people talk about a change in the economic base of an area, they are referring to a change in the basic business sectors.

Sectors other than basic sectors generally do not generate "new dollars", but rather operate on the circulation of dollars already present in the economy. Therefore, nonbasic sectors do not initiate a multiplier effect themselves, but instead contribute to the multiplier effect of basic sectors by preventing leakage. For communities on the Pacific coast, the basic sectors are often resource-based. Examples of basic and nonbasic sectors are (not necessarily in any order of importance):

Basic Sector Examples	Nonbasic Sector Examples
Fish harvesting/processing	Medical services
Logging and timber processing	Movie theaters
Tourism and recreation	Grocery stores
Transfer payments	Banking services

Transfer payments include such things as social security payments, retirement payments, and non-local government salaries. Activities such as fishing, being a form of recreation, would be considered a basic sector industry for that portion of expenditures made by anglers whose residence is other than in the area they are fishing.

b. Multipliers and Coefficients

i. Output (Sales) Multipliers

How is the effect of a dollar of export sales multiplied in a local economy? Suppose an industry increases export sales by $1,000. If the economy has an output multiplier of 2.49, total business sales through the county are expected to increase by a total of $2,490 as a result of the $1,000 increase in exports and the $1,490 in local sales generated by these exports. (The 2.49 is used as an example only. The actual output multiplier may be different.)

Figure B-2 demonstrates how local respending of the export payment by businesses and households creates this multiplier effect. The process begins when a dollar enters the local economy, in this case as the result of an export sale (column A). The dollar will be respent by the exporting firm in order to purchase inputs (goods, services, labor, taxes, profits, etc.) to meet the increased export demand (column B). Sixty cents of the dollar will be received by local businesses and households, but $0.40 will leak out in the form of nonlocal purchases. Thus, in addition to the initial dollar, business respending has generated an additional $0.60 of business activity within the economy. Of the $0.60 that is locally received, $0.38 will be respent within the county, and the rest ($0.22) will leak out (column C). This process continues until the amount remaining in the local economy is negligible (columns D, E, F). Thus, greater leakage at any round of respending leads to a smaller multiplier.

In order to determine the total value, the initial dollar is added to the sum of the local respending. In this example, the multiplier equals 2.49 ($1.00 initial change + $0.60 + $0.38 +$0.20 + $0.12 + $0.08 and so on until it approaches $2.49). Thus, $2.49 of local business activity will be generated for each dollar that enters the local economy. The same process can be used to explain a decrease in export sales.

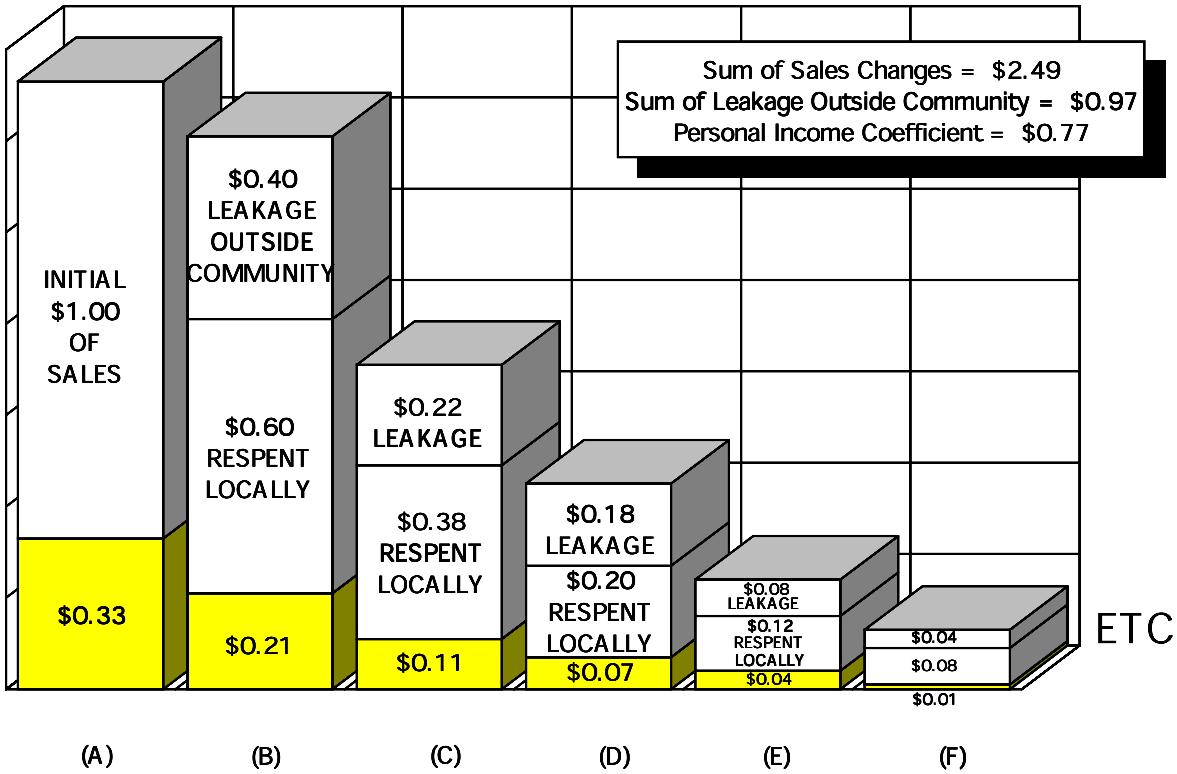
The output (sales) multiplier calculates how much money is "stirred up" in the economy, but it does not mean that someone in the local area is making a wage or profit from this money. The differences between output multipliers and income coefficients are often confused, leading to misuse. People, especially decision-makers, need to know and understand what type of multiplier or coefficient is being used in the assessment of the economics of proposed policy decisions.

ii. Personal Income Coefficients

A more useful measurement of the contribution of a sector's activity is the amount of local personal income that is directly and indirectly generated from an increase in sales. The distribution of the amount of local personal income generated is the shaded part of the output (sales) multiplier.

The "personal income coefficient" measures the income generated as a result of a change in sales. In the first round of export sales, $0.33 of local personal income is generated. The other $0.67 in the initial round goes to purchase supplies and services from other industries.

Figure B-2
Output (Sales) Multiplier and Personal Income Coefficient



Note: The shaded portion of the output (sales) that goes to households in terms of wages, salaries, and profits is called personal income.
Source: Radtke and Davis (August 1994).

These industries also create wages, salaries, and profits. As these sales work through the economy, a total of $0.77 of personal income is generated from every $1 of increase in sales.

The size of the personal income coefficient is largely determined by the amount of personal income generated by the first round. In an industry that is very labor intensive, the output (sales) multiplier may not be very large while the income coefficient is above average. On the other hand, if the industry goes through several transactions but is not very labor intensive throughout the process, the output (sales) multipliers may be large and the income coefficient small.

The impacts estimated in this report are effects on total personal income, the amount that is retained as household income (salaries, wages, and proprietary income). Because many jobs in the fishing industry are not full-time, an employment figure could be misleading. A full-time equivalent employment figure can be calculated by dividing the total personal income figure by a representative annual personal income average. In the Pacific Northwest, a $20,000 to $25,000 per year wage or salary is a fair representative of a full-time equivalent job.

C. Regional Economic Impacts Model Application

I/O models have been constructed for the Pacific Northwest coastal counties with the use of the IMPLAN model. On the commercial side, representative budgets from the fish harvesting sector (Figure B-3a) and the fish processing sector, as well as a price and cost structure for processing are used to estimate the impacts of changes. On the recreational side, a charter operator budget and recreational fishermen destination expenditures (Figure B-3b) provide the basic data. The individual expenditure categories are used as input into the IMPLAN I/O model to estimate the total community income impacts.

1. Commercial Fishing Regional Economic Impacts

Representative budgets from the fish harvesting sector and the fish processing sector, as well as price and cost for processing are used to estimate the impacts or contributions of commercial salmon fishing (for more detail see Carter and Radtke 1986). The commercial fisheries data were developed by Hans Radtke and William Jensen in connection with a project to develop a fisheries economic assessment model for the West Coast Fisheries Development Foundation. For illustrative purposes, Figure B-4 displays example regional impact estimates for two species (chinook and coho) by gear.

For example, gillnet-caught fall bright chinook command $1.50 per pound. The yield on this dressed fish, when it is marketed fresh, is 80 percent. The sales price for the primary product for the fisherman is $2.94 per pound. The community income received from this one pound is $2.86; people in the State outside the local area, that supply goods or services to local area, will receive another $0.50, for a total of $3.36. The total state income generated by one pound of salmon harvested and processed in the Pacific Northwest is $3.36. The average weight of these chinook is 18.4 pounds. Thus, the total state level impact per landed chinook is $61.74. For a troll caught fish landed at $2.30 per pound (round weight), the income impact per fish may be $52.44. The harvesting and processing of hatchery fish may generate $2.24 per pound or $41.22 per fish, especially if additional processing, such as canning or smoking, takes place. For fresh fish sales, because there is less labor involved, this impact may only be $29.52 per fish. The economic impact of a commercially harvested salmon depends on many factors, as shown on Figure B-5.

In some remote areas, "direct selling" to consumers is taking place. In these cases, the consumer travels to rural areas on the Columbia River to purchase a salmon/steelhead from tribal harvesters. Usually, wholesale (only harvesting and primary processing) and retail margins are not included in impact analysis. The reasoning is that these sales would take place in the area of analysis regardless of production. In this case, where the consumer travels to the point of harvesting/selling, these margins may be included for community level impact analysis, but not at the state level.

For example, a $0.50 ex-vessel price ($0.63 dressed) would increase by about $0.65 by the primary processor, another $0.20 by the wholesaler, and another $0.65 by the retailer, for a total of $2.12 per pound. The direct sales of salmon to consumers on the Columbia in 1997

Figure B-3a
Commercial Fishing Expenditures

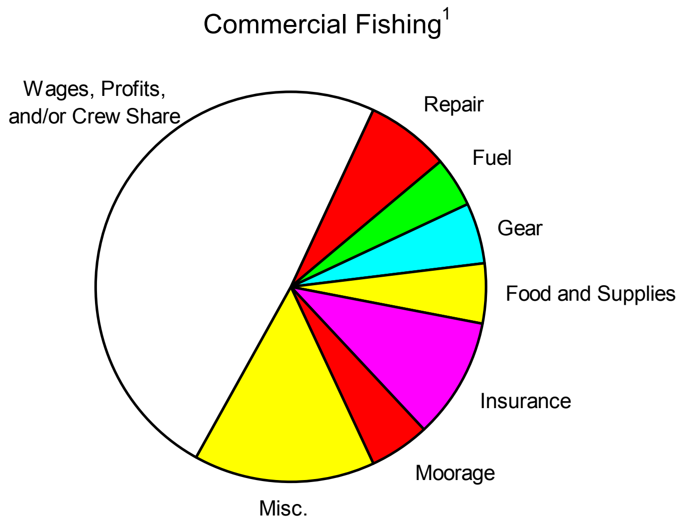
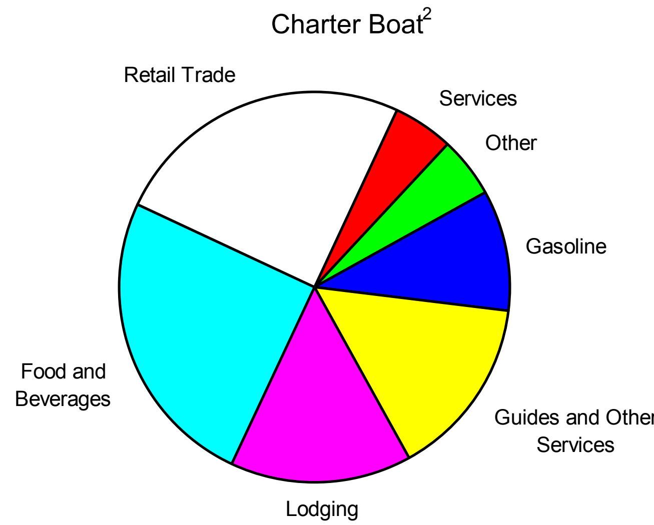


Figure B-3b
Charter Boat Angler Expenditures



Sources: 1. Radtke and Jensen (1986).
2. The Research Group (1991).

was reported to be between $1.75 and $2.00 per pound. Depending on the expenditure patterns of the harvester/retailers' direct sales, the local impacts would most likely be similar to the impact estimates developed by the FEAM for harvesting and primary processing.

Changes in any of these factors will result in a change in the total income impact of salmon landed in an area.

2. Recreational Fishing Regional Economic Impacts

In 1991, a comprehensive survey to compile information about angler characteristics, expenditures, and preferences of recreational anglers was completed for the Oregon Department of Fish and Wildlife (ODFW) (The Research Group 1991). This study completed estimates of economic impacts for seven management zones, eight species categories, and four water types. The economic impact estimates were completed with the same process of disaggregating the IMPLAN model and estimating impacts relating to specific expenditure categories. This study is the basis for the Pacific Fishery Management Council (PFMC)'s annual economic impact of the salmon fisheries (PFMC 1998). These estimates were developed by the State of Oregon and are used by the Pacific Council to estimate regional impacts from California to Washington. The assumption in this report is that these estimates also reflect, in a general way, the economic impacts of salmon harvested in Canada and Alaska.

The estimates of economic contributions to Pacific Northwest personal income associated with recreationally-fished ocean salmon are shown in Figure B-6. Factors affecting this include

Figure B-4
Representative Community and State Personal Income Impacts of Salmon Per Pound

Gillnet Fall Bright Chinook

Landed Price: **$1.50**

Processor

Yield	Sales price per pound of processed product
80%	$2.94

Marginal Income Impacts per Landed Pound

Coastal Community	Rest of State	Total State Income
$2.86	**$0.50**	**$3.36**

Impact per 18.4 pound fish = $61.82

Troll Chinook

Landed Round Price: **$2.30**

Processor

Yield	Sales price per pound of processed product
87%	$3.54

Marginal Income Impacts per Landed Pound

Coastal Community	Rest of State	Total State Income
$3.99	**$0.70**	**$4.69**

Impact per 11.21 pound fish = $52.57

Hatchery

Landed Price: **$0.48**

Processor

Yield	Sales price per pound of smoked or canned product
50%	$4.00

Marginal Income Impacts per Landed Pound

Coastal Community	Rest of State	Total State Income
$1.90	**$0.34**	**$2.24**

Impact per 18.4 pound fish = $41.22

Source: Study and Radtke and Davis (August 1994).

Figure B-5
Factors Affecting Income Generated from Commercial Fishing

Commercial Fishing

- Purchase patterns of fishing businesses (landed price per pound)
- Yield of product
- Type of finished product
- Purchase patterns of processors (sales price of processed product)
- Spending patterns in local economy
- Size of local or regional economy

Source: Radtke and Davis (August 1994).

the means of fishing, expenditures patterns, and success ratios (Figure B-7). It is also important to have legal access to the fish during the time they become available in any specific area. It is assumed there will be access to these fish when they return.

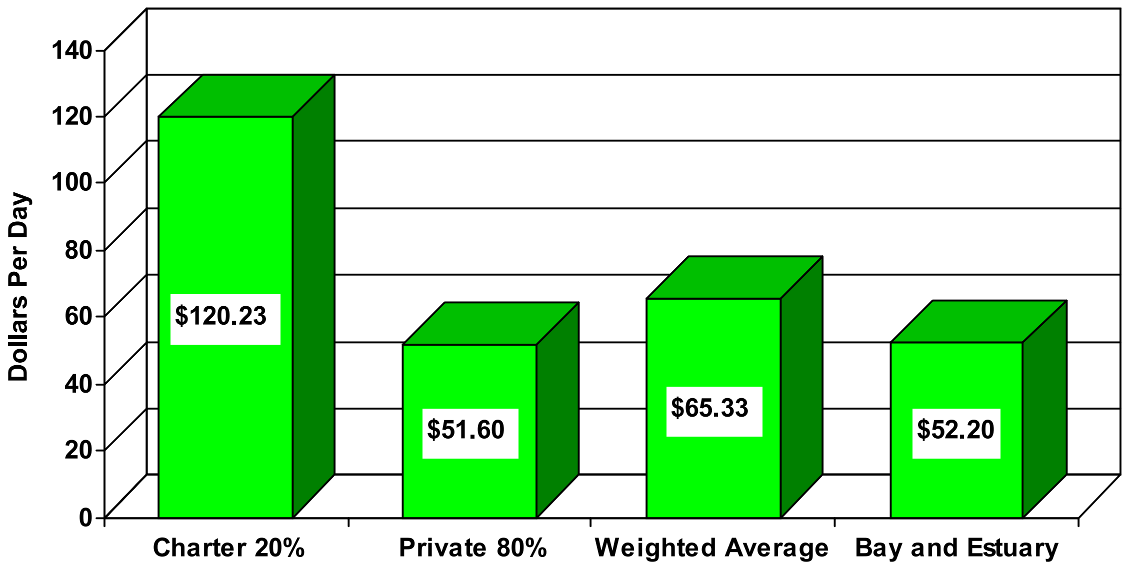
The commercial fishing unit estimates are for personal income impacts per fish. The recreational fishing unit estimates are for personal income impacts per recreational fishing day.

Since 1980, the success rate in ocean salmon fisheries in the PFMC jurisdiction has been about one fish per day (Radtke and Davis, April 1994). Therefore, the coastal community impact for the destination expenditures for charter boat patrons plus the charter boat fee is $102.20 per day (state impacts are $120.23) (Figure B-6). A weighted average for the two means of fishing is $55.53 per day for local income impacts (state income impacts are $65.32) based on an 80/20 private/charter split. This may range widely depending upon area and species. Unless otherwise documented, a one fish per angler day is a reasonable success rate to use. This is based on a historical average for most salmon fisheries that average about one fish per day.

As a general guideline, the economic impacts per salmon/steelhead harvested recreationally in this study is $60 per day at the state level and $50 per day at the community level. For ocean fishing, one fish per day success rates are used. Within the Columbia Basin, the success rates vary from species to species and by geographic area. Chris Carter, Economist for the ODFW (Carter, March 1999), utilizes a one fish per day success rate for ocean fishing and up to two days per fish success rates for inland fishing.[1] For tributaries above the Columbia/Snake

1. There are intuitive reasons that give support to the argument that anglers prefer large chinook and that it would take smaller success rates to entice anglers to fish for chinook. There are no studies available to support this reasoning. For this reason, the same impacts per fish (coho or chinook) are used in this paper. Historical data suggest that each recreational fish "supports," on the average, roughly one day of recreational fishing (Radtke and Davis, April 1994). It is tempting to conclude that each additional recreational fish caught in the ocean would produce a community income of $65.33 (Figure B-6). Depending on the circumstances, this could be an incorrect inference. The number of salmon made available to recreational fishing may result

Figure B-6
Typical Personal State Income Impacts Per Day and Percent of Total Effort From Salmon Recreational Fishing (1997 Dollars)



Notes: The percentage of charter/ private boats are assumed to represent the actual charter/private boat harvest of salmon in the Pacific Ocean (and Columbia River terminal area).
Source: PFMC (1998) and Seger (1996).

confluence, two days per non-retained fish success rates are utilized (Bowler 1999). For steelhead retained, the fish per day success rate is 5.88 days. The steelhead surveys were used as an indicator for future salmon fisheries in Idaho.

D. Net Economic Value Model Applications

Estimates of net economic value of commercial and recreational anadromous fishing are made using available studies and procedures developed by management agencies, such as ODFW,

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in large amounts of fish being available to the recreational fishery. As a result of such large increases, the recreational fish limit may have to be increased. With such an increased bag limit, and supposing the average catch per day increased to three salmon, the income impact per average recreational salmon is reduced because fewer recreational days were "supported" per sport allocated fish. If it can be clearly shown that additional numbers of fish can be released to attract additional angler days, then the average impacts used may be used as an estimate of total impacts. For calculating income impacts of chinook, the means of harvesting may not matter a great deal as long as the angler success rate remains at about one fish per day. That is because the economic impacts per chinook salmon harvested commercially or recreationally are about $50 to $60 per day. The point could even be made that it would be more beneficial to harvest chinook (especially spring chinook) commercially if the bag limits and success rates are higher than one fish per day. The same case could not be made for coho salmon, since a commercially caught coho will generate about $15 if harvested commercially versus about $50 to $60 if caught by the recreational fishing industry.

Figure B-7
Factors Affecting Income Generated by Recreational Fishing

Recreational Fishing

- Means of fishing (charter, private)
- Expenditure patterns
- Success ratio (average fish per day)
- Spending patterns in local economy
- Size of local or regional economy

Source: Radtke and Davis (August 1994).

PFMC, and the National Marine Fisheries Service (NMFS). Estimates of net value utilized in this report should be viewed as general values. Specific uses in selective areas may change these values.

1. Commercial Fishery Net Economic Value

To compute the net economic benefits from commercial fishing the costs of harvest (fuel, repairs, labor, etc.) should be subtracted from the gross revenues (ex-vessel price). Because the fishing season is of short duration, most fishing boats are not limited to salmon fishing. The investment in boat and gear is also used for other fisheries. Also, at low levels of total salmon harvest and with small incremental changes in salmon production, it is often argued that any increased harvest could be taken with almost the same amount of labor, fuel, ice, etc. as before. Since the current fisheries (both the harvesting sector and processing sector) are greatly overcapitalized, in use of fixed and operating capital as well as labor, this is a plausible assumption. This assumption implies that almost no additional costs are involved and gross benefits are close to net benefits.

Generally, any valuation of salmon species involves a geographic area and a salmon species for which there are many substitutes. In such cases, the demand curve is relatively flat. That is, if consumers are faced with a rise in the price of one type of salmon in one area, they will simply shift their consumption to an alternative salmon product. In such cases, there are no extra benefits that could be counted resulting from consumers' willingness to pay different prices for a specific salmon product. Therefore, most economic valuations involving salmon will center on the benefits that a producer receives from the harvesting and processing of salmon.

The assumption of full employment is implicit in most benefit and cost analysis. But unemployment and excess fishing capacity, both transitory and chronic, seem to prevail in many Pacific coastal communities dependent on commercial fishing. Changes in markets or fishing opportunities may make it necessary for people and capital to change occupations and/or locations. Various factors make it difficult for this to happen quickly enough to prevent a period of unemployment and idle capacity.

The Water Resources Council (1979) suggests that when "idle boats" are available, the only incremental costs of increased harvest will be the operating costs.[1]

Rettig and McCarl (1984) make recommendations on the calculations of commercial fisheries NEV's. Their recommendations range from 50 to 90 percent of ex-vessel prices.[2] Because primary processing is an integral part of producing salmon, a portion of the primary processor margins are also used to calculate the net economic value of commercial fishing. Huppert and Fluharty (1996) utilized only the harvesting ex-vessel price and concluded that "All of these estimates are at or below the 50 percent net earnings rates suggested by Rettig or McCarl." (Rettig and McCarl 1984). (Processor margin is the difference between their purchase price, ex-vessel price, and their sales price.)

In periods of reductions, the 90 percent rule would be appropriate. However, if the total salmon harvest increases, it might not be appropriate to use the 90 percent level. A more appropriate level might be the 50 percent level (the lower level recommended by Rettig and McCarl (1984)). In a situation where new resources (capital and labor) were needed to harvest and process a greater amount of salmon, the actual additional costs of harvesting and processing would have to be deducted from the ex-vessel price and the processors' margin in order to arrive at the NEV of additional salmon harvest.[3]

Because it is difficult to collect data on the commercial salmon fishing industry for specific areas and specific gears and almost impossible to compare such estimates on a wide geographic and industry basis, a general guidance may be to present information on ex-vessel basis (properly defined so as to be comparable) and on a first level primary processing basis. (This being the minimal amount of processing required to move the fish out of the region - dressing, icing, packing, etc.) The first level processor basis should be used because in many areas tendering costs and other costs and incentives of specific fisheries may not reflect the actual ex-vessel prices. It may also be argued that the first level processing in any area is inseparable from the harvesting component.

A portion of the ex-vessel and ex-processor prices are therefore used as measures to facilitate guidelines in any of net value of commercial salmon fishing. Specific fisheries with acceptable

1. The estimates of "net value" of tribal harvest may be conservative. This conservative approach may be balanced by assumption of ex-vessel prices that may be received by in-river tribal harvests (Water Resources Council 1979).
2. In many small coastal communities, there are no substitutes for the processor involved in the primary processing of salmon. Much of the salmon is partially processed on board the boat. For these reasons, the harvesting and primary processing is included. Wholesale and retail margins are not included. The basic reason is that demand curve is expected to be flat, thereby no appreciable "surplus." For retailers selling seafood, there are also a host of substitutes available.
3. Note: Chronic underemployment of human and capital resources on tribal lands may result in very low incremental costs resulting from increased harvest opportunity. Other studies have suggested that the average cost increase with increased harvest opportunities may be two to nine percent (Barclay and Morley 1977). A two percent cost was utilized by Meyer in the Elwha Study (Meyer et al. 1995).

data can be investigated to determine the net value of the fishery. For this analysis, in order not to complicate the presentation, a 70 percent margin is used to represent an "average" NEV for most commercial salmon harvested. The 70 percent margin is applied over a range of annual prices. The remaining 30 percent represents additional expenses of harvesting and primary processing required to produce a consumer product from Columbia River Basin anadromous fish runs.

2. Recreational Fishery Net Economic Value

This section summarizes available information on the economic values of sportfishing for Columbia Basin anadromous fish. While there are many studies of anadromous sportfishing values in other locations, there are relatively few studies directly linked to Columbia Basin salmon. This report reviews past studies, including their scope and limitations, and reports the most current economic values available.

a. Review of Previous Valuation Studies

There have been a number of studies of the economic value of fishery resources, both ocean and inland. The proceedings from the 1988 AERE conference on the economic value of marine and sport fisheries (AERE 1988) contain a number of papers on this topic, as well as references to many more. Most of the journal literature is concerned with theoretical and methodological issues related to estimating nonmarket economic values, but most also contain an empirical application to a particular fishery resource. Few of the studies, however, are directly relevant to Columbia and Snake River fisheries.

Studies that have been done in the Pacific Northwest include the early study by Brown, Singh, and Castle (1965) on salmon and steelhead fishing in Oregon, and the follow-up studies by Brown and his colleagues (Brown et al. 1976 and Sorhus et al. 1981). The 1977 data collected by Sorhus, et al (1981), has since been used by Strong (1983) and Loomis (1989) in other applications. Loomis, Provencher, and Brown (1990) also estimated regional travel cost models for Oregon coastal streams using this same data set. A version of the Loomis, et al, model is available in a PC program called "GAMEFISH" that allows the user to estimate the effect of changes in fish catch on net economic value (Loomis and Provencher 1986).

Other Pacific Northwest fishery studies include the study by Johnson, Shelby, and Moore (1989) on the Chetco River winter fishery, studies by Meyer (1982), Meyer, Brown, and Hsiao (1983), and Olson, Richards, and Scott (1990) on the Columbia River fishery, a study of Washington steelhead anglers by Demirelli (1988), a recent study of Snake River steelhead fishing by Normandeau Associates (1998), and the work by Bergland and Brown (1988) on ocean salmon fishing. A study on the Rogue River produced economic values for different fishing seasons (Olson and Richards 1992).

None of the previous studies provide exactly the information needed for making management decisions on the Columbia and Snake River systems. However, they do provide some reference points for comparison. Studies from other regions provide a wealth of information on the theory and methods of economic valuation of fishery resources in general. Table B-1 lists the economic values from selected studies in the Pacific Northwest. Values have been updated to 1998 dollars, and standardized to a value per day basis.

The values for salmon and steelhead range between $22 and $78 per day. The values for ocean salmon fishing range between $32 and $89 per day. The earliest study was done in 1962, and the most recent was done in 1998 on the Snake River. Both the TCM and the CVM have undergone methodological refinement over this time period, which makes it difficult to precisely compare estimates between studies.

Using previous studies (i.e., benefit transfer) to estimate a single value for salmon or steelhead in the Columbia and Snake River systems is problematic for a number of reasons. Previous studies likely used methodologies that have since been improved, would have had assumptions and conditions that aren't currently relevant to the Columbia/Snake system, and socioeconomic and demographic variables could have changed significantly over time. Despite these limitations, the range of values from these studies is relatively small (within $56 of each other), and could be used for lower and upper bounds in a benefit-cost analysis. If the decision from the benefit-cost analysis did not change from the lower to the upper bound, then the analyst could feel relatively confident in the value estimates. If a single value was required (instead of a range), then it would be preferable to focus on studies that were most relevant to the Columbia and Snake River systems. For steelhead, that would be reference numbers 70 (TCM and CVM), 58, 64, 50, 54, and 19. The average value across those studies is $52.85. For salmon, the most relevant studies would be reference numbers 64, 58, and 50, and the average value is $51.43. These average values show that steelhead are slightly higher valued than salmon, which is consistent with studies where both salmon and steelhead have been valued using the same methodology in the same location.

b. Anadromous Fish Values

A few studies report values for both salmon and steelhead (Table B-2). These are noteworthy because they allow a comparison of salmon vs. steelhead values in situations where the study date and method are the same. In all cases, the value of steelhead is greater than the value of salmon per day. Offsetting this higher value for steelhead is the fact that more anglers fish for salmon vs. steelhead. In Oregon in 1989, there were 582,872 salmon angler days, and 359,179 steelhead angler days (The Research Group 1991). Figure B-8 shows that, in Oregon, the steelhead catch has been declining since 1984, while the salmon catch has been generally rising. The economic value of salmon and steelhead in any given river will be a function of the value of the species and the number of anglers fishing for each.

c. Net Economic Value Discussion and Conclusions

The values in this report should be used with caution. Many studies in other locations will not have angling characteristics that are similar to those found in the Columbia and Snake River systems. However, they can give a starting point to discuss sportfishing values in these rivers. More precise estimates would require a major data collection and analysis effort.

The sportfishing values of the Columbia and Snake Rivers represent the economic benefits to salmon and steelhead anglers for the opportunity to fish in these rivers. Some of the past studies estimated these values when anadromous fish and substitute rivers were fairly abundant. Current fish stocks may be much lower, and future policies could close some of the substitute rivers, making the remaining rivers more valuable. The location of rivers closed and left open will affect the relative value of different rivers.

These sportfishing values only represent use value of the salmon and steelhead resource. There are also option and existence values to consider. The more endangered the salmon or steelhead runs are on any river, the more important these nonuse values become. In cases where the overall runs of salmon become endangered, nonuse values can easily be greater than use values. Previous studies have estimated existence values for salmon on the Columbia River and the Elwha River.

The values in this section include both river and ocean fishing values. A large part of the value of river fish runs comes from their contribution to ocean stocks. Both the recreational and commercial value of ocean fishing have to be considered when assessing the total value of anadromous fish in any river.

As in estimating economic impacts, a one fish per day is used as a proxy for valuing anadromous fish produced in the Columbia River Basin and harvested in the ocean. The general guideline is that, for recreational use value, $52.85 for steelhead and $51.43 for salmon per day (and therefore per fish) represents the value that recreational anglers place on an anadromous fish produced in the Columbia River Basin. When there was additional information, this was utilized. For inland fishing below the confluence of the Snake/Columbia, consideration is given to Chris Carter's value estimates (Carter 1999), which basically use a success rate of one fish per day for ocean fishing and coho inland fishing. For inland fishing, the rate varies from about one day per fish for coho to two days per fish for steelhead and spring chinook. (Estimates of days per fish are based on Carter's economic value assumptions of $50 per fish for coho, $75 per fish for fall chinook, and $100 per fish for steelhead and spring chinook.) For tributary fishing, according to the results from Loomis (1999), the value of a day of fishing in the studies is $63.23.

Table B-1
Salmon and Steelhead Values - Selected Studies

	LOCATION	REF#;DATE	METHOD	$1998 per day /1
Steelhead				
	Idaho	70;1986	TCM	22.77
	Oregon	73;1983	TCM	27.41
	Idaho	70;1986	CVM	32.33
	Oregon	11;1983	TCM	34.64
	Oregon	12;1980	TCM	35.86
	Rogue	57;1992	CVM	38.69
	Oregon	38;1986	TCM	43.39
	OR/WA	58;1990	CVM	43.72
	OR/WA	64;1984	TCM	44.23
	Columbia R.	58;1990	CVM	58.30
	Oregon	50;1983	TCM	69.34
	Idaho	54;1998	TCM	73.57
	Washington	19;1988	TCM	78.54
Salmon				
	Oregon	38;1986	TCM	20.99
	Oregon	12;1980	TCM	25.50
	Rogue	57;1992	CVM	29.97
	OR/WA	64;1984	TCM	32.44
	Alaska	28;1991	CVM	37.57 -69.70
	OR/WA	58;1990	CVM	41.16
	B.C.	14;1987	CVM	58.04
	Columbia R.	58;1990	CVM	61.99
	Oregon	50;1983	TCM	70.13
Ocean Salmon				
	B.C.	14;1984	CVM	32.16
	Oregon	64;1962	TCM	37.61
	Washington	17;1978	CVM	40.49
	Oregon	4;1988	TCM	50.02
	Oregon	50;1980	TCM	61.92
	OR/WA	58;1990	CVM	64.53
	Washington	64;1984	TCM	88.47
Salmon and Steelhead				
	Oregon	10;1965	TCM	37.61
	Chetco	33;1989	CVM	36.38
	Oregon	9;1976	TCM	55.43

Notes: 1. Based on gross domestic implicit price deflator.
2. See Table B-3 for reference number mapping.

Table B-2
Salmon vs. Steelhead Values - Selected Studies ($1998)

LOCATION	REF#;DATE	SALMON	STEELHEAD
Oregon	12;1980	25.50	35.86
Rogue	57;1992	29.97	38.69
OR/WA	64;1984	32.44	44.23
Idaho /1	26;1973	94.01	184.87
Oregon	38;1986	20.99	43.39
OR/WA	58;1990	41.16	43.72

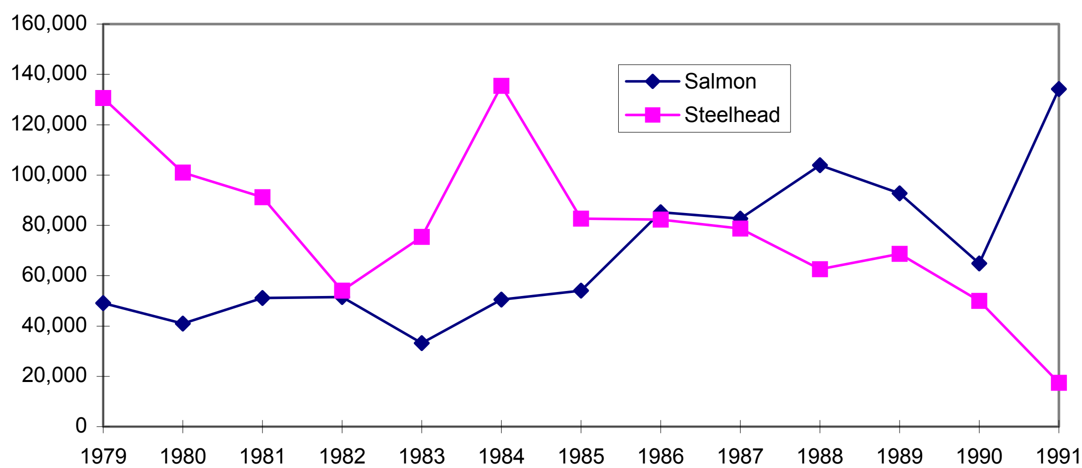
Notes: 1. This study is included in this table to show the relationship between salmon and steelhead values estimated within a single study, but is not included in the previous table because the methodology was not consistent with other studies.
2. See Table B-3 for reference number mapping.

Table B-3
Studies Used to Determine Benefit Transfer Unit Value

Ref. No.	Author	Ref. No.	Author
4	Bergland and Brown (1988)	33	Johnson et al. (1989)
9	Brown et al. (1976)	38	Loomis (1986)
10	Brown et al. (1965)	50	Meyer et al. (1983)
11	Brown et al. (1983)	54	Normandeau Associates (1998)
12	Brown et al. (1980)	57	Olsen, and Richards (1992)
14	Cameron and James (1987)	58	Olsen et al. (1990)
17	Crutchfield and Schelle (1978)	64	Riely (1988)
19	Demirelli (1988)	70	Sorg and Loomis (1986)
26	Gordon et al. (1973)	73	Strong (1983)
28	Hanneman and Carson (1991)		

Note: Full citation is included in References section.

Figure B-8
Salmon and Steelhead Catch in Coastal Rivers



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ATTACHMENT C

JOHN DAY DAM
ANADROMOUS FISH
MITIGATION HISTORY

John Day Dam Mitigation History[1]

The implementation of John Day mitigation has resulted in much controversy. The intention of this review of the John Day mitigation history is to provide the U.S. v. Oregon Policy Committee a basis to compare current John Day mitigation production.

John Day Dam was authorized by the Rivers and Harbors and Flood Control Act of 1950 (Congress 1950). House Document 531 includes the U.S. Army Corps of Engineers' (USACE) recommendations for mitigation measures due to construction of the Dalles and John Day dams. The USACE proposed a joint two or more unit hatchery to mitigate for the loss of fall chinook spawning areas above The Dalles and John Day dams. The hatchery units would be constructed along the lower Deschutes River, above the backwater of The Dalles Pool. These units combined would have a capacity to handle about 25,000 adult fish, and would require about 50,000,000 eggs. The costs of the proposed hatchery units would be jointly borne by The Dalles and John Day dams.

Perhaps because production facilities were proposed as mitigation for both dams, little action was taken on the proposed hatchery on the Deschutes until the early 1960s when the Fish and Wildlife Coordination Act (FWCA) reports for John Day Dam were written. On August 8, 1963, the Bureau of Sport Fisheries and Wildlife (BSFW, now known as the USFWS) and the Bureau of Commercial Fisheries (BCF, now known as the NMFS) sent a joint report to the USACE with a description and justification for artificial propagation facilities to mitigate for John Day Dam (BCF and BSFW 1963). This report was based on an earlier report prepared by the Fish Commission of Oregon (FCO) and Washington Department of Fisheries. The proposal described in House Document 531 for a hatchery on the Deschutes was retained in the 1962-63 recommendations, and a large 600-acre rearing facility was added on the Washington shore adjacent to the John Day Reservoir. The proposed holding capacity at these facilities was approximately 30,000 female and 10,000 male adult chinook salmon spawners, and 150,000,000 eggs with 60,000,000 fry to be reared at the Oregon facility and 60,000,000 fry to be reared at the Washington facility. Although there was some uncertainty as to the type of fall chinook that spawned in the reach to be inundated by John Day Dam, the agencies decided that tule fall chinook would be the race of chinooks that would be sorted out at John Day Dam for artificial propagation in the hatchery.

The fishery agencies of Oregon, Washington, and Idaho concurred with the 1963 FWCA report. After the 1963 FWCA report was presented to the USACE, the USACE hired consultants to review the fishery agencies' proposals. A key difference between the agencies' proposal and the USACE consultants' analysis focused on the maximum number of spawning fish to be mitigated. The fishery agencies estimated a maximum number of 60,000 adults, whereas the USACE consultants estimated a maximum number of 24,000 adults. The USACE consultant numbers were very close to the USACE original mitigation proposal of 25,000 adults for both The Dalles and John Day dams. Subsequent studies and discussion led to the proposal to develop a program for providing hatching and rearing facilities for 75,000,000

1. This Attachment is excerpted from TAC 1997).

eggs (15,000 females) to produce an annual release of 30,000,000 fingerlings at 100/pound with a minimum production of 12-15 million fingerlings.

Locations of the mitigation facilities were also modified. The Deschutes River was abandoned as a suitable area for a hatchery and the focus was on the area below Bonneville Dam (as requested by the state fishery agencies of Oregon and Washington). In 1966, the states proposed sites for the Lewis River in Washington and the North Santiam River in Oregon (BCF 1966). In 1967, after the USACE investigations determined these sites were unsuitable (USACE 1967), the state and federal agencies proposed expansion at Oxbow Hatchery near Cascade Locks in Oregon, and the Spring Creek National Fish Hatchery (NFH) near Underwood in Washington (BSFW and BCF 1967). By August 1968, after Sohappy v. Smith was filed in Federal District Court, the Fisheries Director for the FCO wrote to the Walla Walla District Engineer to inform him that Oregon was looking at releasing the John Day mitigation fish from the Bonneville Hatchery (below Bonneville Dam). The John Day Dam was also completed in 1968. By February 1969, after U.S. v. Oregon was filed, Oregon's position was that John Day mitigation fish should be released at Bonneville Hatchery (FCO 1969). The rationale for the state's position was that fish released above the dam would be subjected to significant downstream mortality by the USACE proposed power peaking plan and the Bonneville Second Powerhouse proposed for construction. In April 1969, the federal fisheries agencies informed the USACE that they desired mitigation for John Day Dam to be accomplished at Bonneville Hatchery instead of Oxbow Hatchery (BCF and BSFW 1969). The federal fishery agencies' stated rationale was that the fish would make a greater contribution to the sport and commercial fishery if juvenile fish were released below Bonneville Dam and returning adults were collected, held and spawned at Bonneville Hatchery.

The completion of John Day Dam resulted in the inundation of fall chinook spawning habitat. A mitigation program was developed during the 1960s and early 1970s by the USACE and several state and federal fisheries agencies designed to compensate for the lost production. As agreed to by these parties, hatcheries would be used to replace the lost natural production of 30,000 adult
fall chinook salmon in the flooded John Day Pool and that 17,100,000 fall chinook fingerlings would be reared and released annually at a size of 90 fish per pound (total 190,000 pounds). Originally, efforts to achieve mitigation were made by utilizing an early spawning stock of fall chinook (tules) produced at two fish hatcheries (Bonneville Hatchery and Spring Creek NFH). However, during the late 1970s and early 1980s, parties involved with the original mitigation plan development decided that the upriver bright stock would better represent fall chinook production lost due to construction of the dam. During this time period, it was also expressed that mitigation hatchery releases should be made in the area of loss. Up until 1982, the tribes were not consulted on the John Day mitigation program and were not party to any of the discussions or agreements. The original plan between the USACE and the fishery agencies included revisiting the mitigation agreement after hatchery evaluation studies were completed in 1995. The John Day mitigation programs are described below.

Spring Creek NFH: The Spring Creek facility is operated by the USFWS and is funded by the NMFS (Mitchell Act) and the USACE (John Day mitigation). Spring Creek NFH was expanded and modernized in 1972 as part of John Day mitigation.

Subsequently the production of both URB and BPH stocks declined and survival rates decreased. After attempting for years to overcome these production problems, the URB production was transferred to Little White Salmon NFH, leaving only BPH production at Spring Creek Hatchery. Since the transfer survival rates of both stocks have increased. The BPH production has been increased to 15 million subyearlings annually. The CRFMP Appendix B identifies a short term production adjustment of 15-16 million BPH subyearlings.

Bonneville Hatchery: Bonneville Hatchery was expanded by the USACE for the purpose of meeting half of the mitigation responsibilities for the construction of John Day Dam. The facility is operated by ODFW. Bonneville Hatchery was programmed to produce 8,550,000 juvenile fall chinook at 90 fish per pound. The first production from the expanded facilities at Bonneville Hatchery occurred with the 1976 brood. Approximately 22,000,000 fall chinook tule fingerlings were liberated at Bonneville Hatchery. About 8,500,000 of these resulted from the expansion of the facility. The first attempt at rearing URB fall chinook at Bonneville Hatchery also occurred with the 1976 brood. Approximately 89,000 Snake River fall chinook were reared and transferred to the Kalama Falls Hatchery in Washington in the fall of 1977. Beginning in the fall of 1977, URB fall chinook were trapped from Bonneville Dam fish ladder and spawned at Bonneville Hatchery. These trapped URBs were used to establish a broodstock and evaluate their use in mitigating the loss of spawners in John Day Pool. The CRFMP Appendix B refers to the Bonneville Hatchery program as an egg bank.

Little White Salmon NFJ: Following an unsuccessful attempt to rear URBs at Spring Creek NFH, the program was moved to Little White Salmon NFH in 1988. The facility is operated by the USFWS and is funded by the NMFS (Mitchell Act). Although John Day mitigation funds are not provided to the Little White Salmon NFH, the CRFMP Appendix B identifies a John Day mitigation level of 1,100,C00 URBs at this facility with a short term program adjustment of 5,400,000 URBs. This rearing program currently includes the release of 1,700,000 into the Yakima River.

Priest Rapids Hatchery: Priest Rapids Hatchery is operated by the WDFW. The CRFMP Appendix B identifies a production goal of 10,000,000 URBs. The facility now releases 5,000,000 URBs due to a change in fish per pound strategy. In addition to this production, 1,700,000 are released designated as John Day mitigation (URB) and are funded by the USFWS as part of Little White Salmon Hatchery commitment.

In 1992, the TAC submitted a report to the U.S. v. Oregon Policy Committee which provided an assessment of pre- and post- John Day Dam project production (TAC 1992). The TAC noted that in a 1978 mitigation agreement, hatchery production would mitigate for the annual spawning escapement of 30,000 adults and all of the fish contributing to ocean and inriver fisheries. The report was intended to provide the parties with an analysis of whether John Day mitigation activities were resulting in the intended adult returns and contribution to fisheries. The TAC concluded that during the years 1958-67, annual adult production of John Day Reach URBs ranged from 93,000 to 121,000 adults (mid-point 107,000 adults). John Day mitigation makes up a major portion of the MCB production (56% of total releases since 1985). Annual adult production of MCBs during 1982-89 averaged only 56,500 adults. MCB production in the three-year period of 1987-89 was within the range of 93,000 to 121,000 adults, but it was likely that overall John Day mitigation production was below the range of 93,000 to 121,000 adults. The TAC also concluded that most of John Day mitigation releases have been below Bonneville Dam or in the Bonneville Pool and do not provide returns to the area impacted by the John Day Dam. The TAC report also noted that if future releases are to be transferred to rearing and acclimation sites upstream, consideration will have to be given to compensation for reduced survival rates. Following the TAC report, the parties discussed the original intention of John Day mitigation. Some parties contend that the mitigation responsibility was to produce a certain number of adults for harvest and hatchery broodstock. Other parties contend the mitigation responsibility was only to produce and release specific numbers of juvenile fish.

Disagreements on specific features of the mitigation program persist. Although the original plan (between the USACE and the fishery agencies) included revisiting the mitigation agreement after hatchery evaluation studies were completed in 1995, the tribes have expressed interest in accelerating the schedule of renegotiations. The magnitude of hatchery releases, release locations, marking levels, and acclimation strategies are among some of the issues. The reporting of the 1995 evaluation studies is not available.

Effects of Mitchell Act Funding Reductions

The Mitchell Act was originally enacted in 1938 to provide for the conservation of the fishery resources of the Columbia River (Congress 1938). The Mitchell Act was perceived as an emergency measure to protect the valuable salmon resources of the Columbia River which were threatened by the construction of Bonneville and Grande Coulee dams. The locations of the salmon culture stations or irrigation screens and other passage facilities were not specified in either the statute or legislative history. Ten years passed before the Columbia River Fishery Development Program (CRFDP) proposed 31 hatcheries in 1948. All 31 proposed hatcheries were below the Deschutes River except three which were on the Yakima, Tucannon, and John Day rivers. The Mitchell Act hatchery program was initiated with $1 million authorization for Fiscal Year (FY) 1949. From FY 1949 to FY 1961, funds for construction and operation of CRFDP facilities were appropriated to the Department of Army, Corps of Engineers, for transfer to the USFWS. Beginning with FY 1962, CRFDP appropriations were made directly to the Bureau of Commercial Fisheries in the Department of Interior and later to the NMFS in the Department of Commerce. Most of the construction under the CRFDP occurred during the 1950s and the early 1960s. Twenty-two hatcheries were constructed or expanded under the program.

The majority of the Mitchell Act-funded production has been coho and tule fall chinook below Bonneville Dam. However, Mitchell Act funds are used to produce other species as well as some production above Bonneville Dam. In recent years, Congressional appropriations language has directed that a portion of fish from lower river hatcheries be released upriver to rebuild upriver natural runs. There has been some progress in this area, though not to the degree expected by the tribes.

Starting with FY 1996, substantial reductions in Mitchell Act funding has occurred. As a result, the State of Oregon has decided to end several tule fall chinook programs below Bonneville Dam. This major program change will reduce the LRH contribution to ocean fisheries off the coast of Washington and in Canadian fisheries as well as lower Columbia River fisheries. Some coho programs are also likely to be curtailed or ended, thus reducing contribution to ocean and inriver coho fisheries.

Although many of the Mitchell Act program reductions are occurring below Bonneville Dam, there are indirect consequences to upriver hatchery programs as well as harvest management. The specific facility plans for Mitchell Act program reductions are still unclear.

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